ISSN 1085-0708

CQ VHF

Ham Radio Above 50 MHz

www.cq-vhf.com
Summer 2005
$6.50

Planning for the First 10-GHz California to Hawaii QSO

- Rover Techniques for Various QTHs
- Grid Locators or Grid Squares?
- Bats and an RDF Adventure

■ VHF/UHF Weak Signal ■ Microwaves ■ Amateur Satellites
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A publication of
CQ Communications, Inc.
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Hicksville, NY 11801 USA.

Offices: 25 Newbridge Road, Hicksville, New York 11801. Telephone: (516) 681-2922. FAX: (516) 681-2926. E-mail: cq-vhf@cq-vhf.com. Website: http://www.cq-vhf.com. CQ VHF (ISSN 1085-0708) is published quarterly (4 times a year) by CQ Communications, Inc. Periodical postage paid at Hicksville, NY and additional offices. Subscription prices (all in U.S. dollars): Domestic—one year $25.00, two years $45.00, three years 65.00; Canada/Mexico—one year $35.00, two years $65.00, three years 95.00; Foreign—one year $38.00, two years $71.00, three years 104.00. Government Agencies: Subscriptions to CQ VHF are available to agencies of the United States government, including military services, only on a cash with order basis. Requests for quotations, bids, contracts, etc., will be refused and will not be returned or processed. CQ VHF does not assume responsibility for unsolicited manuscripts. Allow six weeks for change of address.

Printed in the United States of America.
Postmaster: Please send change of address to CQ VHF Magazine, 25 Newbridge Road, Hicksville, NY 11801.

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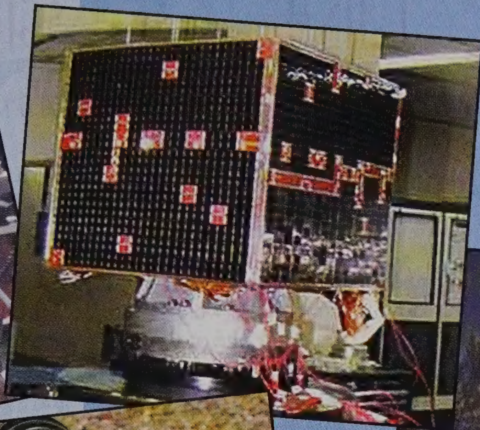
Summer 2005
Vol. 8 No. 2

FEATURES


COLUMNS

DEPARTMENTS

On The Cover: How are a batmobile and hidden transmitter hunting related? When you strap transmitters on bats' wings, you have to have a chase vehicle and a team to man the vehicle. For more on this bat-fulling story, see the "Homing In" column by KØOV beginning on p. 32.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

One Thing Leads to Another

During the course of my editing duties I was reading the article "California to Hawaii Attempt on 10 GHz" by Features Editor Gordon West, WB6NOA (beginning on page 6), when I came across his reference to Ralph "Tommy" Thomas, KH6UK. As Gordo explains, Tommy, along with John Chambers, W6NLZ, was a pioneer in discovering and exploiting the California to Hawaii propagation duct.

I have been an admirer of Tommy, not only for his pioneer work in Hawaii when his employer, RCA, transferred him out there for a few years to be the engineer-in-charge of the company's transmitter at Kahuku, Oahu, but also for his having made the first 2-meter meteor-scatter contact with Paul Wilson, W4HHK, on October 22, 1953. I had wondered what happened to Tommy since I interviewed him in 1994 for my VHF column in *CQ* magazine. Knowing that he was in his 90s then, I rather doubted that he was still alive. Even so, I did the most logical thing, something many of us do when we check on fellow hams: I looked him up on QRZ.com. What I discovered led me on a detective trail that would lead all the way back to Hawaii.

Upon arriving at Tommy's information at QRZ.com, I was saddened to read in the biography section that Tommy was a Silent Key. I figured as much, after reading his date of birth as 22 December 1903. However, knowing that he had died only served to pique my curiosity. My first clue was the fact that someone had taken the trouble to write in his biography section "Ralph Thomas is a Silent Key." Who had made the updated entry? Was it a relative?

I sent an e-mail to Fred Lloyd, AA7BQ, the owner of the QRZ.com website, asking him for permission to find out who had updated Tommy's information and explaining that I wanted to do a piece on Tommy for a future column in *CQ*. In response, Fred graciously assisted me in getting in touch with that person.

As it turns out, the person is Mark Shultise, WA3ZLB, who happens to be Tommy's nephew. In our initial correspondence Mark sent me copies of three newspaper articles dating back to the 1950s and 1960s. One bit of trivia that fascinated me concerning the first California to Hawaii contact between Tommy and John was found in one of those articles.

In *The Sunday Home News,* New Brunswick, New Jersey, the Sunday, August 4, 1957 edition, I read the following:

> Thomas made history in Hawaii last month when one of his experiments with Very High Frequency signals resulted in contact with a California amateur operator 2,600 miles away at virtually the same time a massive meteor flared in the Hawaiian skies.
>
> Veteran electronics operators on the island report it marked the very first time such contact had been made between Hawaii and the mainland. They attribute it to one of two things: (1) Freak atmospheric conditions, or (2) A meteor shower.

Their assumption that their contact was a result of a meteor shower rather than via the previously unknown weather-created duct is not surprising in retrospect. It was only four years earlier that Tommy had made that first meteor-scatter contact with Paul on the same band. It would be a couple of years of frequent communications on 2 meters plus setting a still-standing DX record on 220 MHz on June 22, 1959 before John would deduce that the propagation was weather related.

Another seemingly trivial item in Mark's initial e-mail intrigued me. He began it by writing "Aloha Joe." Who else but someone living in Hawaii would greet someone with the word "aloha"?

It turns out that after an initial vacation trip to Hawaii in 2002, Mark decided to return there for good. He has become a Kona Coffee farmer and lives on the big island of Hawaii. His QTH is Captain Cook, which is a two-hour drive from Pahoa, the QTH of Paul Lieb, KH6HME, who as you will read in Gordo's piece is the Hawaiian-side contact for the potential 10-GHz QSO. What an incredibly small world we live in!

I have forwarded Paul's phone numbers to Mark and will leave it up to them to make contact with one another. Hopefully, the nephew of the pioneer of the California to Hawaii duct might possibly be a witness to another pioneer setting yet another record between California and Hawaii. Whatever happens, you will read about it in this magazine and in my column in *CQ*. Speaking of *CQ* magazine, I plan to have more about Tommy in my September column.

New This Issue

With this issue we welcome Bob Witte, KØNR, as the new FM column editor. Bob also writes a QRP column for *QRP Quarterly.* He has received great cooperation from Gary Pearce, KN4AQ, the outgoing editor, in his transition to becoming the new editor. Even so, Bob needs to hear from you as he establishes himself as the new editor. His first column begins on page 44.

Also in This Issue

On page 14 you will find an article by Features Editor Ken Neubeck, WB2AMU, on the past ten years of VHF activities on the lower VHF+ ham bands. In addition, on page 20 is part one of a two-part article on roving by Paul Goble, ND2X, and Wayne Gardener, N4FLM. Also, beginning on page 26, is an article on the misnaming of grid locators by Emil Pocock, W3EP. As usual, you will find the regular columns by your favorite columnists spread throughout the magazine.

Next Issue

In the next issue of *CQ VHF* we hope to establish yet another column related to our specialty of VHF communications, that being radio control. We have been in touch with Del Schier, K1UHF, who is considering writing a regular column on that subject. Del writes for *Fly RC* magazine. Watch for the next issue to see what develops.

And Finally . . .

Thanks to your support this magazine continues to grow, both in the number of regular writers and in readership. We really appreciate your support, which continues to inspire us to commit to more and more excellent coverage of this specialty within our wonderful hobby. If you have an idea or project that you would like to consider publishing, please contact us and we will discuss developing it with you.

Until the next issue… 73 de Joe, N6CL

The California to Hawaii Attempt on 10 GHz

This summer Chip Angle, N6CA, and Paul Lieb, KH6HME, will attempt to contact one another on 10 GHz via the well-known California to Hawaii propagation path. Here WB6NOA covers the history of the VHF and above records held to date via the circuit, as well as the difficulties Angle and Lieb are facing in their attempt to establish yet another microwave record.

By Gordon West,* WB6NOA

This summer hams from southern California and Hawaii hope to establish a world-record terrestrial tropospheric ducting contact on the 10-GHz X-band. Chip Angle, N6CA, has spent the last few years completing final assembly, final testing, and final alignment of all of his homebrew equipment in Hawaii and his portable equipment at the U.S. mainland side of the circuit. Chip indicates the equipment is more than ready at each end of the 2400-mile path, and favorable July tropospheric ducting weather will hopefully move in, settle in, and create the path.

A Well-Known Path

The southern California to Hawaii VHF/UHF tropo path has been recognized for over 50 years. The military, conducting Operation Tradewinds, regularly established a San Diego to Hawaii path on VHF frequencies during summer months. It was also during the 1950s that internationally known VHF/UHF DXer John Chambers, W6NLZ, began VHF operating schedules in Hawaii with Tommy Thompson, KH6UK.

Sure enough, on July 8, 1957 John and Tommy made contact on 2 meters, and on June 22, 1959 they again made contact on 220 MHz. Back in the 1950s, 432 MHz was characterized as too high in frequency because of the 2400-mile path loss, yet Chambers indeed worked up a 432-MHz system and *heard* Tommy's signal from Hawaii. However, as life moved on, Tommy moved back to New Jersey, returning to his old callsign W2UK, and was not able to complete the path. For quite a few years after the W6NLZ to KH6UK contacts no one in Hawaii had that special fascination with VHF/UHF tropo ducting and the microwaves above.

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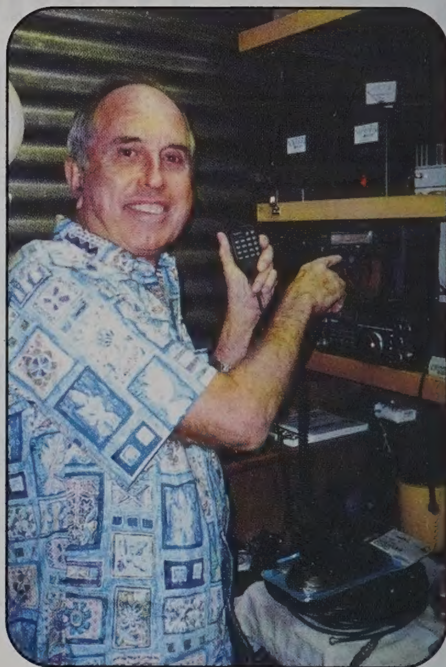
Then Along Came Paul, KH6MHE

Twenty years went by with no California to Hawaii activities except for a few summertime reports of California 2-meter repeaters, where 20-watt mobile stations claiming to be in Hawaii were saying "aloha" for several hours on end. Of course, no one believed that an AM signal on 2 meters would ever propagate over the 2400-mile path, so the Hawaiian mobiles were told to quit pulling our legs and move on to another repeater.

Paul Lieb, KH6HME, was a southern California transplant to the big island of Hawaii. Paul was fascinated with the tropo ducting possibilities between Hawaii and the mainland, so he and Bob, W6PJA, assembled a 432-MHz beacon inside a tin shack on the side of the Mauna Loa volcano, 8200 feet above sea level. The shack was not very warm, as it gets chilly at that altitude. However, it was full of television translators who didn't mind an affable ham taking up a few feet of bench space to squirt a signal over a nearly impossible 2400-mile path back to the mainland.

Once operating, Bob was the first to hear the new beacon. Next the 432-MHz signal was armchair copy for Louis Anciaux, then WB6NMT, now KG6UH and HL9UH, whose home was perched on San Diego's Point Loma, at nearly the exact same spot as some of the original military tradewind tropo experiments. It took Paul several hours to navigate the lava roads to get up to the beacon site. Once the beacon's signal dropped, the first 432-MHz contact was established on July 18, 1979, followed by the first CW 432-MHz contact made by Jay Mahoney, W6YDF.



Paul Lieb, KH6HME, gets set for 10 GHz this July and August.

In June 1981 Chip, N6CA, built and shipped to Paul the 1296-MHz beacon. Sure enough, a after a couple of years trying they made the first 1296-MHz contact. On a day when Chip heard the beacon, he jumped in his 1976 Chevy van and coordinated with Paul on 2 meters SSB for an easy CW two-way on 1296 MHz. Chip's transverter was running 1 watt via a TRW-52601 transistor driven

Chip Angle, N6CA, ready to establish the 10-GHz record for the first QSO from California to Hawaii.

by a Motorola transistor to a rat-race mixer with a milliwatt at 28 MHz for injection. The output fed a water-cooled (mobile!) 7289 driver tube that delivered 30 watts output. This drove a 180-degree ring hybrid homebrew setup that split the signal into two 15-watt levels. These two signals drove two individual 7289 amplifiers in parallel for a maximum power output of 500 watts. However, with a little experimentation on the air, it was quickly realized that weather conditions were far more important than brute power in completing the 2400-mile path.

In the 1990s Chip sent more equipment to Paul, and they become regulars in setting microwave records, conquering 902 MHz, 2.3 GHz, 3.3 GHz, and finally 5.6 GHz, all on CW without the aid of a computer pulling signals out of the mush. In the meantime, members of the San Bernardino Microwave Society were going hot and heavy on 10 GHz SSB, scoring valuable finds from the aerospace industry and the monthly swapmeet at TRW!

July 15, 1994 was the first major effort to establish a 10-GHz contact with Paul in Hawaii from the southern California mainland. Chip had developed a very nice 10-GHz system that Paul could get on the air to a fixed 10-GHz antenna aimed squarely at southern California. Jack, N6XQ, began X-band calls to Paul, followed by an evening attempt by Dave, WA6CGR, who was located near Los Angeles International Airport. Frank, WB6CWN, was on Sunset Ridge near Claremont overlooking the Los Angeles basin, and he too tried to hear the 10-GHz beacon and establish a two-way contact on X-band.

Robin, WA6CDR, also lit off his monster 10-GHz dish antenna. Even with major power levels from TWTs, the monster dish antenna still could not bridge the path, even though VHF and UHF beacon signals were so strong that I was able to talk from an FM handie-talkie to Paul over the 2400-mile path with full quieting! However, nothing on 10 GHz.

Studying the Path

Over the last ten years Chip and members of the San Bernardino Microwave Society have studied the path between Hawaii and southern California, collectively sharing ideas on how to improve the microwave systems at both ends of the circuit. Chip completely redid both stations for this year's 10-GHz California to Hawaii world-record QSO attempt.

"I am satisfied that my new 10-GHz system for KH6HME will establish our 10-GHz Hawaii to California contact," commented Chip, who was featured in the April 2005 issue of *QST* for all of his accomplishments on VHF, UHF, and microwaves.

"*CQ VHF* readers can ride right along with me on the bench and see the projects for the Hawaii efforts I have completed by linking to my website: <http://www.ham-radio.com/n6ca>. To see the construction pictures of the KH6HME 10-GHz station, go to <http://www.ham-radio.com/kh6hme> and click on the "Construction Pictures" link," added Angle.

The KH6HME X-band system yields 10.3 watts at the feed horn, with a 1.6-dB noise figure. A WR-90 waveguide and a W2IMU feed are used for the 0.6 f/D Prodelin offset feed, 48-inch Ku band, 40-dBi dish. The 10 watts comes from a Hughes 1177H TWT amplifier. Chip converted LNBs for the pre-amplifiers and direct up/down conversion to 28 MHz using his own design of bandpass filters, which he constructs in his well-equipped lab at his home.

Was the reason the 10-GHz signal was never received because mainland and Hawaii weren't locked on the same frequency? No problem now, as the entire system is frequency-locked to a Ball Rubidium frequency standard, which has the local oscillator calibrated to within 1 Hz. By contrast, Chip says that it was probably not that the stations were on different frequencies, but rather inaccurate dish antennas were probably the greatest contributor to the lack of success on the previous 10-GHz attempts.

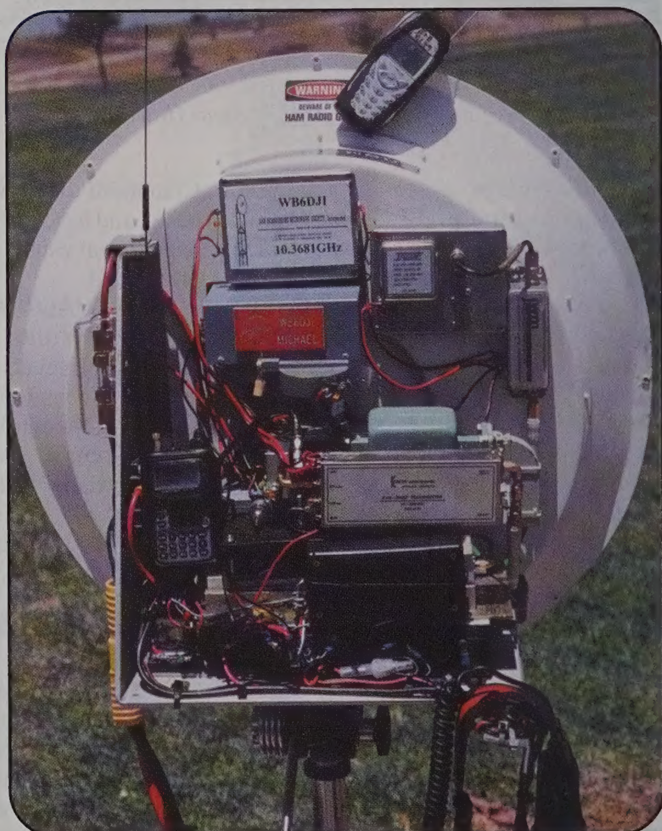
This Summer's 10-GHz Efforts

Paul says he is sure that equipment problems in the past have been solved, so this year he is definitely ready for the 10-GHz efforts. "Statistically, July is always our best month for tropospheric ducting, and I will have all of Chip's equipment in place and up and running for the 2400-mile effort," he added. Paul regularly spends three months in southern California during the holiday season and the rest of the time on the big island of Hawaii, where he works down by the water near Hilo. Upon hearing from the mainland that propagation is present, he instantly jumps in his vehicle and heads for the Mauna Loa volcano operating site, a modest 2-hour drive along a lava field road which saw a lava flow go through it just a few years ago.

"It is always exciting up on the hill. I tune into the FM broadcast band coming in from the states as I head up to the 8200-foot elevation. This gives me a good idea of how strong the duct is open to California. I also watch the cloud layer; when the blanket of clouds is just below the operating site, conditions usually will be great on all VHF and UHF bands, and hopefully soon the X-Band!" said Lieb, smiling as he poses for a quick photo

The Hawaii tin shack up 8200 feet, where Paul, KH6HME operates up to a week at a time trying for the 10-GHz record.

The 10-GHz tuneup and test put on by the San Bernardino Microwave Society.



Both SSB Electronics and Down East Microwave modules are popular with 10-GHz microwave operators.

beside the southern California Ed Tice house, where Ed and Paul often talked about the California to Hawaii tropo path. Coordination for the X-band attempt usually takes place on the 2-meter band or 70-cm band. If X-band propagation is favorable, 2 meters and 70 cm over the 2400-mile path will always be at a peak.

Chip added, "We have shipped Paul some hardline connectors and cables for a new 2-meter rebuild at the Mauna Loa end of the circuit. Paul will be running a pair of 7-element M^2 Yagis pointed at southern California from the Mauna Loa volcano site. The upgrade to his 2-meter operation was accomplished through donations from the Western States Weak Signal Society (http://www.wswss.org); Mike Stahl at M^2; and myself, plus a lot of tweaking before everything got shipped to Paul and Fred, W6YM, over in Hawaii."

Once a month about 40 X-band (and higher!) operators get together as part of the San Bernardino Microwave Society (http://www.ham-radio.com/sbms). "Our monthly SBMS meeting turnouts pack the house, because many of our members bring show-and-tell microwave gear," explained President Chris Shoaff, N9RIN. He indicated that the $15 per year membership and newsletter keep everyone's interest high and further all of the efforts going into this year's 10-GHz try between California and Hawaii. Each summer before the two 10-GHz ARRL contests SBMS members turn out on a rural city park test range for receiver, frequency, and power-output checks.

"Put up a 10-GHz horn at any hamfest gathering and it's like a magnet, attracting hams to see what happens at 10,000 MHz," commented Kent Britain, WA5VJB, who is a member of the North Texas Microwave Society (http://www.ntms.org) and *CQ VHF*'s "Antennas" columnist.

This same "show-it-off" technique was also a big draw at the recent Amateur Electronics Supply Superfest, with 10-GHz demos put on by the local Badgers contesters microwave team (Marc Holdwick, N8KWX, president, <n8kwx@arrl.net>). "We

make it a point to show off 10 GHz to VHF and UHFers to get more operators onto X-band," explained Holdwick, an echo of what the Northeast Weak Signal Group (http://www. newsvhf.com) and Mt. Airy VHF Radio Club (http://www.ij-net/pack-rats) are also doing to promote X-band excitement. At their respective annual conferences, the Southeastern VHF society (http://www.svhf.org) and the Central States VHF Society (http://www.csvhfs.org) also make it a point to conduct public 10-GHz microwave demos to encourage more hams to jump into the action.

Has this article begun to pique your interest? You don't need to completely homebrew your 10-GHz station. Many companies have equipment that is literally plug-and-play! Among them are SSB Electronics USA (http://www.ssbusa.com); Prodelin (http://www.prodelin.com); and Down East Microwave (http://www.downeastmicrowave.com).

"We have complete 10-GHz TX/RX systems that may easily be configured with most VHF or 10-meter multi-mode rigs," commented Gerry Rodski, K3MKZ, of SSB Electronics USA. "These complete systems are not light-weight either," added Gerry, referring to power outputs at 10 GHz at the 2- and 3-watt levels! This could easily make possible a QSO with Hawaii if conditions are right this summer along the southern California coastlines.

There will be over 300 West Coast hams listening in on the 2-meter Hawaii beacon frequency (144.170) for an opening. As the tropospheric duct begins to build, there may be as many as 100 West Coast hams relaying reception reports to the ducting website maintained by Russ Sakai, KH6FOO, at: <http://hiloweb.com/kh6foo/bbs/subduct.html>. When the 432-MHz beacon from Hawaii starts pounding into the West Coast at above S-9, the word goes out to 10-GHz operators.

"By the end of July, or at the latest the middle of August, we should see success from all of our 10-GHz efforts," said Chip. By the time you read this article, the word may have spread on weekly ham news broadcasts that the 10-GHz record was set. Over 40 southern California X-band operators hope to follow up on Chip's initial record-breaking contact, furthering all of the efforts that Chip and SBMS members have put in on the 2400-mile over-water path.

"We are ready! Let's all hope for great Pacific tropo conditions this summer!" exclaimed Chip, ready to jump in his Suburban to head for the hill to complete the circuit. ■

The Classic "Black Widow" VHF AM Transceiver

The once popular Black Widow AM transceivers have all but disappeared from our memory—and from any sources of used equipment. Here N8RG describes how he found and restored a 2-meter version of this radio.

By Ray Grimes,* N8RG

It was in the mid-1950s when *CQ* magazine began to print advertisements for an exciting, new, affordable ham VHF AM transceiver strangely called the "Black Widow." These transceivers were primarily marketed by Arrow Sales, Inc. and their distributors.

The January 1958 edition of *CQ* featured a "*CQ* Reports on" article by Don Stoner, W6TNS, on the Black Widow. The Black Widow AM transceiver was available for 10 meters (TXR11-CQ), 6 meters (TXR10-CQ), 2 meters (TXR9-CQ), and 220 MHz (TXR12CQ) per the Rogers Electronics catalog 27-611, with all being offered at $165 each. There were several options listed, such as an AC-only power supply (Cat. 13861 PS2-CQ) which sold for $27.50, a universal 6V/12V/115 VAC power supply with speaker for $36.50 (Cat. 47611PS3), surplus new 12V dynamotors for $6.95 each, and there was also mention of a future "Plug-In VFO" option that may never have materialized.

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2-Meter Model . $165.00
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RECEIVER: Low-noise cascode RF stage and double-conversion (6 mc and 150 KC) IF's. Oscillator stabilized by VR tube and balanced-coefficient matched capacitors Very-high-Q IF's. 5687 output Has AGC, very effective noise limiter, and an S-meter Easy Vernier tuning.

TRANSMITTER: 2E26 output driven by 5763. Link coupled and matched exactly to 52 ohms with no filter insertion loss. 6U8 xtal oscillator uses stable, dependable overtone circuit. Multiplier and output tank use balanced-coefficient matched capacitors for absolute stability. Includes built-in press-to-talk changeover relay. The S-meter switches to become efficient tune-up meter. Crystal or VFO plugs into front panel for easy frequency change.

MODULATION: Switch selects either carbon mike or high-Z mike, either crystal or dynamic. 6AU6 preamp. 12AU7 phase-inv./ampl. drives P-P 6AQ5s which plate-modulate the final. 100% modulation with no splatter!

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For further information, check number 69 on page 124.

In the mid-1950s CQ *printed advertisements for the Rogers Electronics Black Widow VHF AM transceiver.*

The Black Widow measured only 9 inches wide, 5 inches high, and 6 inches deep and weighed only $7^1/2$ lbs. Those who grew up with the popular Gonset Communicators may never have operated one of these unusual Black Widow radios sets, or they would understand their appeal. I recall seeing Black Widow 2-meter transceivers used on local transmitter hunts, where the proud owners showed off their new radios to anyone who could spare a half hour to listen to a lecture about the virtues of this new radio set. I still can visualize the Black Widow's plain gray, square sheet-metal cabinet, the half-moon panel meter, and the bright-red knobs that looked somewhat like those of the Gonset "Gooney Bird."

The Black Widow was manufactured in West Los Angeles by Rogers Electronics, located near Jefferson Blvd. and Fairfax Blvd., on a side street that once accommodated small light-industrial buildings and modest homes. That area was redeveloped some years ago, and while the Rogers Electronics Carmona Ave. street address still exists, a run-down, four-unit apartment building adorned with a security fence and security grates on the windows now occupies that property.

The Black Widow transceivers were hand-wired and hand-assembled in a garage-shop manufacturing environment. The very basic Black Widow transceiver was designed to be competitive with the fully-accessorized Gonset Communicator II, which sold for $229.95 (in 1957 it was replaced by the improved Gonset Communicator III, which included push-to-talk). The Black Widow sold for $169.95 less speaker, microphone, antenna, and power supply. You could purchase a matching power supply, or build your own, providing 6 or 12 volts for the filaments, and 200 to 300 volts at around 200 ma. No mention of a mobile mounting

The author's Black Widow before restoration. (Photos by the author)

*3212 Tigertail Dr., Los Alamitos, CA 90720

bracket was found in any Black Widow literature, although the service manual states: "Four corner screws permit universal mounting."

A single 2-inch panel meter serves as a receiver relative signal-strength S-meter and a transmitter tuning meter for multiplier and final stages plus modulation indication, selected by a front-panel-mounted rotary switch (below the panel meter). As those were the days when most hams built and experimented with sometimes marginal mobile radio equipment, it was not unusual to have a bare-bones mobile transceiver without a squelch circuit, or a dynamotor power supply that was as loud as the receiver audio.

Rogers Electronics advertised that it had researched the best of current military communications technology of the day and had incorporated it into the Black Widow. The radio does indeed have some good features even though it was truly a low-cost product. The 2-meter Black Widow, for example, has a decent tunable, dual-conversion AM superheterodyne receiver, using a 6BZ7/6BQ7 cascade preamplifier circuit resulting in 0.5 microvolt sensitivity. Sharp receiver selectivity and good image rejection are attained through use of a dual-conversion receiver design with a high IF of 6 MHz and a 1500-kHz low IF. A 6T8 tube serves as detector, AGC, noise limiter, and first audio amplifier. A 5687 dual triode vacuum tube operates as the second audio amplifier and audio output stage, producing $^{1}/_{2}$ watt of audio into a 4-ohm speaker load. A 0B2 tube is the B+ regulator for the receiver local oscillator circuit. The transmitter multiplies the 8-MHz crystal output 18 times to 144 MHz. A single 2E26 tube produces 8 watts of RF output into a 50-ohm unbalanced antenna, with excellent 100% Class AB^2 plate modulation from a pair of 6AQ5s operating in push-pull. An open-frame DC relay is used for antenna and B+ switching functions. There is even a crystal spotter circuit to help find your own transmitter frequency on the variable receiver dial.

The Black Widow featured microphone-operated push-to-talk (unlike most of the more costly Gonset II Communicators). It even offered a carbon/crystal/dynamic microphone selector switch, although it required disconnecting the radio from the mobile mounting bracket and removing the top cover to gain access to the interior chassis-mounted rotary switch. Six- or 12-volt DC operation is fairly easy to implement, but it requires removal of the radio bottom plate and some internal terminal strip jumpering of the filament string. A 6-pin, recessed Cinch-Jones chassis-mount type male connector is provided on the rear panel for all external power and speaker connections.

The Black Widows had a few quirks, as some panel slide switches weren't labeled, but other controls were. The service manual makes note of the location and purpose of the unmarked Noise Limiter switch (lower right corner) and the Spot switch (left side of the panel meter). The transceiver, although designed for low cost, was a brilliant example of 1950s' RF engineering. The 220-, 144-, 50-, and 28-MHz transceivers had the same basic chassis, with certain components deleted for the lower bands. The 28-MHz transceiver had front-panel hole plugs where 144- or 220-MHz multiplier stage tuning controls would have been installed. The Black Widow made extensive use of dual-section miniature vacuum tubes to save space and cost. The cab-

inet provides some ventilation holes and louvers that may have proved to be inadequate for extended mobile or base use in warm environments.

These transceivers were definitely built with low cost in mind, reflected in their hand-made construction. Components such as panel switches, potentiometers, and the panel meter were mounted directly on the formed sheet-metal housing front panel. The radio was assembled around these components, sometimes hiding access to these parts completely. This produced real challenges in isolating troubles and replacing components, where other components had to be removed to gain access to almost inaccessible regions of the cabinet interior.

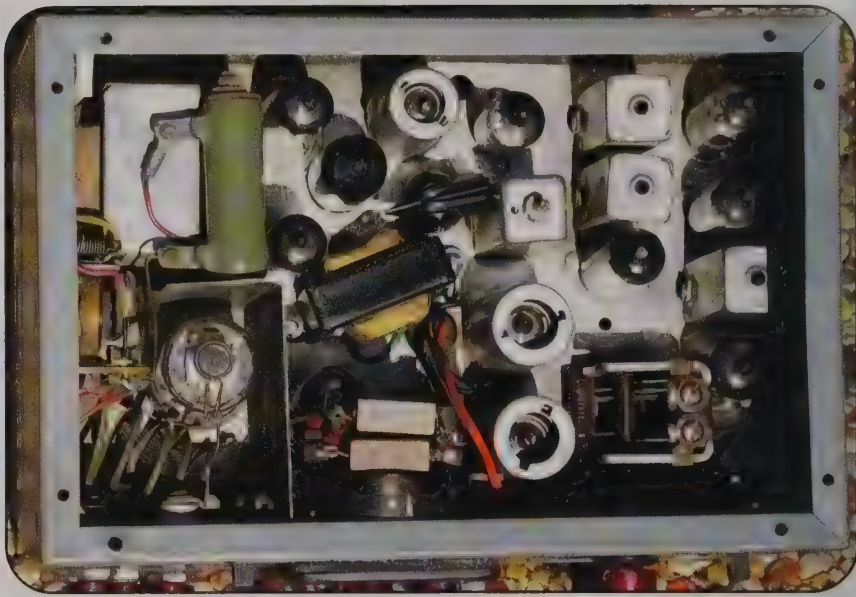
Black Widow transceivers are extremely hard to find these days. After looking for several years for one in any condition, I was fortunate to locate one on eBay. I thought I would be outbid by hundreds of interested buyers, but to my surprise I was the only bidder, capturing this rare find for around $35. I am beginning to believe that before this article is read by *CQ VHF* subscribers there may have been fewer than a dozen of us who even knew what a Black Widow transceiver was (and maybe a lot more who knew but didn't care).

The restoration of my Black Widow 2-meter transceiver was largely a matter of reconstructing damaged and missing parts by close examination of advertising photos and magazine article artists' conception drawings. The Black Widow transceiver I bought had the wrong panel meter installed and exhibited some cabinet rust and wear around the silk-screened control panel's white lettering. The top cover was completely missing. I was able to purchase a complete Rogers Electronics 2-meter Black Widow operator manual from Surplus Sales of Nebraska, including a schematic diagram, complete with engineering sign-offs by J. Rogers in September 1955. That, plus a few magazine advertisements and the Don Stoner article were enough information to get me started on this challenging restoration project.

The Restoration

I decided to salvage and mechanically modify the 0–1 ma., 2-inch panel meter that came with this transceiver, removing the meter movement from its housing and grinding down the round mounting flange. I then made a new black plastic bezel to replicate the original one. As I maintain a good scrap box, some black plastic that looked similar to the original meter bezel was found. The new meter bezel was epoxied to the modified meter faceplate. A new meter shunt resistor was required to balance the meter readings for all metering positions. All transmitter metering functions read normally. The S-meter mode on the Black Widow normally reads backward (right to left action), in the same fashion as the Gonset G-66 mobile receiver. The S-meter circuit has plenty of sensitivity, so it is just a matter of getting used to the reverse meter operation. An S-meter Sensitivity control is provided (below the S-meter, to the right of the meter switch).

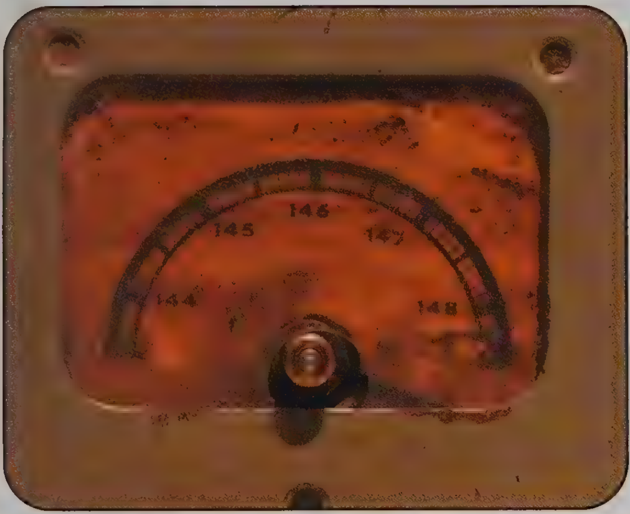
As with almost every old radio, the #47 dial lamps were found to be burned out. Closer inspection also identified a scorched 3500-ohm, 25-watt wire-wound resistor that serves as a B+ current-limiting resistor. It soon became evident that the former owner of this transceiver had a problem with high voltage over-current that was blowing the internal B+ fuse and resorted to wrapping the open fuse with foil paper from a cigarette package. A new 1/4A fuse and a



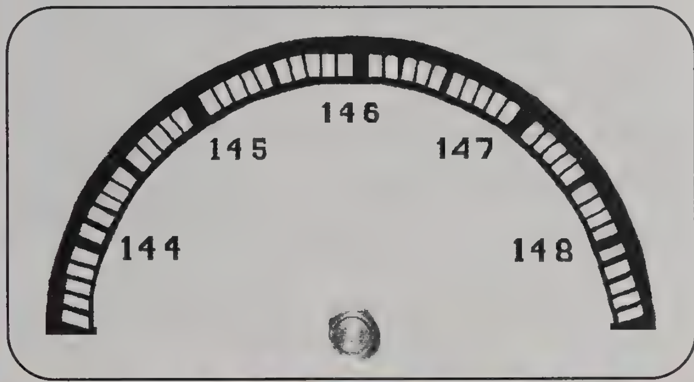
Top view of the now restored transceiver. Notice the new shunt resistor on the back of the panel meter.

Bottom view of the restored transceiver. One can easily see how printed-circuit boards have simplified internal packaging of today's radios.

← The original, badly damaged dial face.



The author's computer-generated replacement dial face.



The restored Black Widow, which resides with the author's other vintage radio gear.

The back of the restored transceiver.

replacement 2E26 appear to have corrected any B+ over-current problems.

I then attempted to remove a badly damaged dial face to replace it with a computer-generated replacement that I would make. I was soon challenged by the economical design of the Black Widow, where some parts simply couldn't be removed without special tools or removal of numerous components. Such was the receiver planetary dial drive assembly. I eventually came to realize that I would have to somehow replace the receiver dial face with the complete dial drive assembly in place. I used the macro lens setting on my digital camera to photograph the badly deteriorated receiver dial face as mounted in the transceiver. I then imported the digital photograph into a photo editing program, spending several hours replacing missing black lettering (pixel by pixel) and digitally erasing countless background blemishes on the dial paper stock while restoring the bright-white dial background. The old dial face was carefully removed, and a new paper dial face was slit at the bottom to fit around the dial shaft and glued into place. The results are impressive, if I do say so myself.

A 12-volt power cable was made and the radio was powered up by slowly bringing up the A+ and B+ voltages to limit inrush current. The radio came to life without hesitation, and after realignment it performed almost completely to the manufacturer's specifications. A 2E26 was the only tube replacement made, bringing the Black Widow up to its rated 8 watts output power. A dynamic mobile microphone was used to check modulation. The open-frame relay was cleaned with contact cleaner, using a relay burnishing tool.

The physical restoration was much more of a challenge than the electronic repairs. The paint was closely matched using semi-gloss enamel spray paint obtained from a hobby store. Careful masking was done to preserve the lettering, and in particular, the Black Widow symbol. The gray paint was feathered by light sanding to blend into the original paint. Press-On Transfer lettering was installed to replace some of the worn panel white lettering and then carefully over-sprayed with a clear acrylic to protect it. The missing top cover became a larger project than expected. I soon discovered that having small louvers stamped into a piece of sheet metal would be expensive. I then began a search for scrap sheet metal with small louvers that could be cut to size. I eventually located a rack cabinet back panel with small louvers that would fit my requirements. The fabricated replacement top cover was cut to size and drilled. The new cabinet top was painted to match and installed.

This restored Black Widow is displayed among my personal ham radio museum pieces. Not only was this a fun restoration project, it was also a history lesson about an enterprising small amateur radio manufacturing business that has faded into obscurity, like so many others over the years. ■

VHF Weak-Signal Activity

A Review of Recent Progress for Three Bands

A lot has happened on the VHF+ bands over the past ten years. In this article WB2AMU reviews these happenings on the bottom three bands, 6 and 2 meters, and 125 cm.

By Ken Neubeck,* WB2AMU

Every once in a while it's a good exercise to take a reality or temperature check with regard to the ham radio hobby. One aspect that is worth exploring is the progress of activity on the VHF bands over the past decade.

VHF is defined as the frequency range from 30 MHz to 300 MHz. In North America this includes three amateur radio bands: 6 meters, 2 meters, and 125 cm (222 MHz). In parts of Europe and Africa there is also another VHF band allocation at 70 MHz (4 meters).

The three VHF bands used by hams in North America have interesting forms of propagation that make certain days special in comparison to the line-of-sight contacts that are made. In this article we will review the progress of weak-signal activity over the past decade for these three bands.

6 Meters

It is now the year 2005, and it can safely be said that 6 meters is no longer the forgotten band amidst all the allocated ham radio bands. A number of things have changed the fortunes of the "Magic Band" over the past decade, and it has become a very popular band during the summer months. Publicizing the many unique propagation conditions of the 6-meter band, ranging from sporadic-*E* to *F*2-layer activity, as well as the availability of more commercially made equipment have increased the band's popularity.

I remember how things were on the band back in 1990, when I first got on 6 meters with a Swan 250 transceiver that I picked up at a local flea market. I found that it was very hard to figure out the nuances of the band and when to listen for any activity. All too often back then 6 meters was quiet, and I wondered when contacts could be made. My first real wave of contacts was during the September VHF contest in 1990. All the contacts I made then were of the line-of-sight variety up to a distance of 200 miles away.

I had heard rumors from other operators that at times the band had skip activity, but available reference material such as the *ARRL Operating Manual* did not clearly spell out what the best times were to listen on 6 meters. Various VHF books discussed some of the propagation modes on the band, but the information presented was of the broad-strokes variety, without specifics.

It was not until June 1991, just hours before a VHF contest, that I worked my first sporadic-*E* contact on 6 meters from my location in Long Island into Florida. Gee, I thought, maybe long-range stuff on 6 meters can be worked after all! When the contest started, I worked a large number of stations and was amazed that a dead band could come to life! Over the balance of that summer I looked at anything I could find about the band (remember that this was before the Internet became really popular), but I could only find general information in the *Operating Manual* about what kind of conditions could be found on 6. Unfortunately, this information was too general for it to be of much use to a newcomer to the band, and much information had to be gained by the laborious process of word of mouth. Because the information was so broad, it made the band seem much more mysterious than it really is.

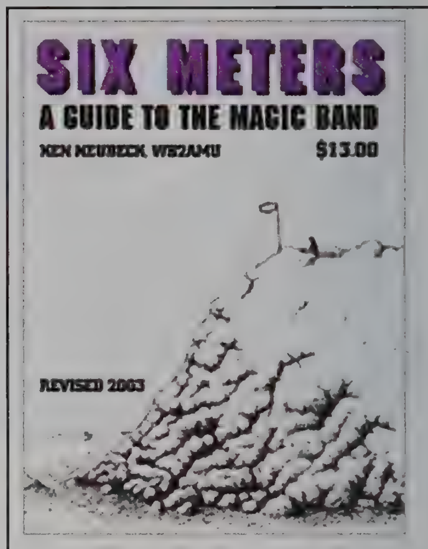


Figure 1. Here is the book that started getting the word out about 6 meters. It still remains the one and only book out there dedicated to 6 meters. First published by WorldRadio Books in 1994, a second edition came out in 1998, followed by a third edition in 2003. Each edition featured additional pages with the current scientific information about propagation along with up-to-date amateur radio observations on the 6-meter band.

It then became obvious that more articles and a dedicated book for the 6-meter band were needed. I had written an article on 6 meters for the December 1992 issue of *QST*, and from that article I was able to write additional articles for *WorldRadio*. In 1993 when that magazine sent out a request to its readers for ideas for books, I suggested that I write a book dedicated entirely to 6 meters. After a few

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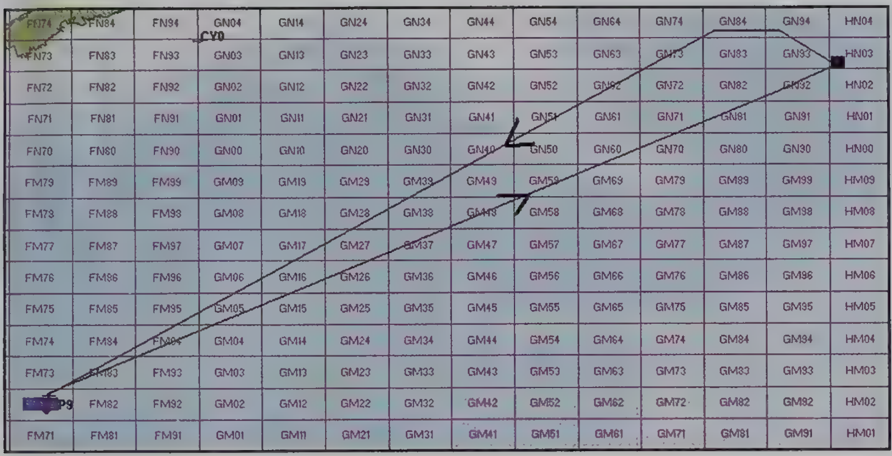

Figure 2. This map, constructed by George, GM4COK, and on his web page, shows George's 6-meter maritime mobile excursion during July 2003 on the cable repair ship Sir Eric Sharp. *He started from Bermuda and went through several rare all-water grids to grid HN03, where cable had to be repaired using an underwater robot that was controlled from the ship. Clint, W1LP, is another well-known maritime 6-meter operator who has navigated through many all-water grids over the years. All-water grids are a real treat for 6-meter operators because of the difficulty of finding operators passing through. (Map by George Szymanski, GM4COK)*

months the staff accepted my proposal and off I went!

I realized right at the conception of the project that I needed the input of 6-meter operators with significant operating experience and from other locations. Thus, with the help of veteran operators such as Tom Glaze, K4SUS, and Frank Moorhus, AA2DR, and the input of others, I was able to put together the first and only book dedicated to just 6 meters, with it debuting at the 1994 Dayton Hamvention® (see figure 1) . The book has since gone into two additional editions, in 1998 and in 2003, with added pages and updated information.

Even after the book came out in 1994, there was still a lack of equipment for the band. A few new radios were available, such as the single-band Yaesu FT-690, the Kenwood TS-60, and the triband Yaesu FT-650. However, this was still not producing the desired results. It was not until the wave of HF plus 6-meter transceivers such as the ICOM IC-706 and the Yaesu FT-100 that a real difference was seen in increased use of the band. Now at times HF operators would check out the 6-meter band with these new transceivers.

Hams who made the journey from HF to 6 meters quickly found that the summertime sporadic-*E* season on 6 was consistent between May and August year in and year out. Some of these openings can be quite intense. Of course, too, aurora backscatter makes an occasional appearance on 6 meters, even during reduced sunspot activity. This was the case in the June 2005 ARRL VHF contest, where a major aurora opening occurred on 6 meters in the U.S. and Canada during the last five hours of the contest, creating a pile-up of CW signals on the band.

No doubt the greatest amount of 6-meter excitement over the past decade came about during the fabulous *F2* openings that started in October 2001 and continued into February 2002. This period of *F2*-layer activity occurred months after the peak of sunspot Cycle 23 and caught many by surprise. In September 2001, the daily solar flux values stayed consistently above 200, and this continued over the next few months, resulting in daily 6-meter openings via *F2*. East Coast stations in the U.S. were working into Europe in the morning, and then in the afternoon the opening would shift between the East Coast and the West Coast. It was truly an exciting time for the 6-meter band!

Six meters easily lends itself to DXpeditions and rare-grid-square expeditions. Over the past decades operators such as Jon, NØJK; Jimmy, W6JKX; and Johan, ON4IQ, have activated a number of rare countries, as well as some rare grids. A most interesting grid-square expedition is the one GM4COK mounted in July 2003, when he operated 6 meters from a ship that worked on underwater cables (figure 2). With a 5-watt FT-817 radio, he activated over two dozen all-water grids, leaving from Bermuda and going into the mid-Atlantic.

There are a number of dedicated 6-meter radio clubs such as SMIRK, the Six Club, and the Southern California 6-meter Club. They keep the flame for 6 meters alive. There are a few dedicated 6-meter Internet sites as well. The best one in terms of active spotting is run by Tim Havens, W4TRH: <http://www.dxers.info>. I cannot emphasize how valuable this website has been, both in terms of the technical information, and the spotting information that is present on the chat page of this site. Many short sporadic-*E* openings, as well as developing aurora openings, have been spotted on this site.

Perhaps the only real issue with 6 meters these days is adherence to the recommended band plan. Strictly speaking, the DX window of from 50.100 to 50.125 should only be used for DX contacts and not for domestic QSOs. Also, the use of both calling frequencies—50.110 MHz for DX and 50.125 for domestic stations—should be used carefully by 6-meter operators. For example, when the band is quiet, a station that gets a response to a CQ on 50.125 might be within the guidelines of good sportsmanship in completing the

Jon Jones, NØJK, used this simple two-element Yagi with good success during one of his earliest trips to Bermuda. (Photo by NØJK)

A three-element, 2-meter Yagi is a small antenna that is easy to set up for portable operations. Here is the setup that WB2AMU employed in searching for 2-meter tropo activity near a 250-foot hill that also features a public park with a Vietnam War monument. (Photo by WB2AMU)

QSO on that frequency. However, if the band becomes more active, it is wise to move up the band and call CQ. During many great sporadic-*E* openings 50.125 MHz becomes a zoo of activity such that it is virtually impossible to complete a QSO. Obviously, it makes sense to spread out on the band.

Another situation is the use of 50.110 MHz. It is fine for a domestic station to call CQ DX a couple of times on the frequency and then stop if there is no answer. There are some stations that call long strings of CQ DX, effectively blocking the use of the frequency by anyone else, be it a DX or domestic station. Good judgment should always be used. Call once or twice, and if there is no answer, move off this frequency.

Six meters continues to grow and it is a major band for VHF contests as casual operators join in on the fun. The June 2005 VHF contest featured sporadic-*E* openings on the west coast of the U.S. while a major aurora event occurred on the east coast of the U.S. and Canada. While the band could be used more for local contacts, overall it is in good shape and will probably continue to grow steadily in activity.

2 Meters

Two meters is the staple of amateur radio, going back to the days when 2-meter FM became king in the late 1960s. Repeaters were the rage on 2 meters FM for a number of decades. Recently, though, cell phones have become more popular.

If you are concentrating on weak-signal or simplex work on 2 meters, you need to take advantage of the propagation modes that occur on the band. The three major modes of propagation enhancement found on the 2 meter band are tropospheric ducting, aurora backscatter, and sporadic-*E*.

Tropospheric ducting is the bread-and-butter mode for the 2-meter band, with aurora backscatter and sporadic-*E* being present during exceptional conditions. In the case of aurora, geomagnetic activity has to be pretty high such that 6 meters is solid with activity. Sporadic-*E* is pretty much the same way and initially may be detected during solid conditions on 6 meters with signals shortening. However, sporadic-*E* on 2 meters is at best a once or twice occurrence during the summer in the U.S. However, as witnessed by the great July 7, 2004 opening, it gives operators a chance to work many new grids in a short amount of time!

I started my participation in VHF contest activity by operating 6 meters only. After several years of participation in the single operator, portable category, I added more VHF bands to my contest activity, including 2-meter weak-signal work. As I had discovered with 6 meters, there are a significant number of quiet times in the weak-signal portion of the 2-meter band. In some ways, 2-meter weak-signal activity has significant hurdles that have to be overcome as compared to 6-meter weak-signal activity. Six meters has many hams championing it when compared to 2-meter weak-signal activity, but the band has an advantage in that *Es* and *F2* openings are worked with modest effort at the right time of the year.

After hearing some of the enhanced tropo conditions on 2 meters during the contest, I also started to listen to the band on a regular basis during non-contest periods. In addition, I started to listen to 2 meters during major periods of geomagnetic activity to work stations via aurora activity.

Occasionally, a path opens from Long Island along the coast into North Carolina. Every so often it seems as if the same area comes in via a strong opening. One station I have worked from this area is Jim, AA3ID. Now while extended tropo paths can often occur in the summer and fall, I actually worked AA3ID during an unusual period of tropo extension in February 2005 at noontime at my work location using a three-element beam suspended from a tree. I also used it to search for tropo activity on 2 meters during the spring of 2005.

(Continued on page 70)

Two meters is ideal for portable operations during VHF contests, too! Here is the same setup used by WB2AMU right after a major blizzard during the January 2005 VHF contest. (Photo by WB2AMU)

The Margelli-Miller Behind-the-Scenes Story

By Gordon West, WB6NOA, and Joe Lynch, N6CL

It was a battle between modern technology (cell-phone text messaging) and old-fashioned CW to see which was faster in conveying a message. The object of the contest was to transmit the message over the air via the respective (cell phone and amateur radio) wireless spectrum. The two ham contestants were Chip Margelli, K7JA, and Ken Miller, K6CTW. The *Tonight Show* is shot before a live audience in near real time, so the challenge was to do the contest right the first time.

Chip reported that there were many technical challenges in pulling off their CW competition in one live take. In particular, the show is shot within a very tight block of time, with little or no time to spare for QRM problems on the ham bands from studio birdies, or vice versa. Chip commented, "Ken Miller, K6CTW, arrived before I did and RF swept the studio area using his portable spectrum analyzer."

"Yikes, our planned RF band was full of birdies. In fact, 160 meters through 2 meters was filled with signals that might have QRMed our efforts to send and receive a usable CW signal. The birdies were ultra low level confined inside the studio, but nonetheless, too many HF birdies to dodge!" he added. Even so, Chip anticipated this problem well ahead of time, so his rigs of choice were a pair of Yaesu FT-817s, battery operated, with UHF capabilities hopefully beyond birdie land! One of the radios belonged to Chip and the other was supplied by Dan Dankert, N6PEQ, a weak-signal VHF operator in the Orange County, California area.

As it turned out, Chip's choice of radio and frequency paid off. "We found quiet on 70 cm," commented Ken, K6CTW, who prepared for a "one take only" performance on the show. Being the good weak-signal VHF enthusiast that Chip is, he made sure that their radios were tuned to 432.200 MHz.

"To further minimize any chance of QRM, Chip and Ken found good signals over the 15-foot path with the FT-817 antenna menu selector to open antenna," noted Janet Margelli, KL7MF, adding that Chip and Ken set the FT-817s to low power with no antenna connections. Even so, they still had good copy over the 15-foot path, and the radios easily tolerated the open antenna circuit with no problems. In spite of this provision, the close proximity of the two radios made it possible for Ken to easily hear Chip's weak-signal CW transmission and thereby copy the message. Best of all, there was no chance of RF getting into sensitive circuits in the studio. It is important to note that the radios were props. While it appeared that Chip and Ken were in contact with each other, legally no QSO actually took place.

Commenting on the time constraint, Janet stated, "We had only the commercial break time to set up the two stations," adding that the setup took place right after Jay Leno's monologue. Janet handled the transmitting station's setup with Bencher paddles at Chip's location, and the receiving station, plus earphones, pen, and paper at Ken's location – all within the three-minute station break! "A quick double check of signal quality and strength took place within seconds of coming back on camera," added Janet, who was one cool cookie under pressure!

The message, a slight variant of GEICO Insurance Company's advertising slogan "I just saved a bunch of money on my car insurance," was secret until the sending started. The contest against the text messengers was an easy win, with Chip and Ken loafing along at around 28 wpm, with time to spare when they finished.

"The rigs worked perfectly, Morse Code wins again, and ham radio gets a great boost on national television," added Chip, who was so pleased with the under-pressure contest that he gave his CW sending fingers a cool blow down and the camera his classic smile, while Ken beamed after perfect copy of the CW sent script.

For ham radio exposure, the *Tonight Show* with Jay Leno did us well, thanks to professional hams who took the assignment just days before air time and undertook the technical setup just seconds before the stage came alive with CW at its best!

Transmitter Testing—Part 2

Reprinted from *DUBUS* magazine, in the second part of this two-part article SM5BSZ concludes his discussion of how to correctly measure transmitter quality.

By Leif Åsbrink,† SM5BSZ

In part one of this article we discussed our justification for transmitter testing, and the average power spectrum and peak power measurements. This time we cover ALC and SSB, measurements using notch filters, and comparisons among transceivers on SSB, as well as present an extended discussion on the results of our testing.

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ALC and SSB

ALC is just a DC-coupled AM modulator which will add the spectrum of the ALC signal to both sides of the carrier. But if the ALC signal has a fast-rise, slow-decay characteristic, the bandwidth of the added modulation becomes very large. It then is essential that the modulation amplitude is very low; other-

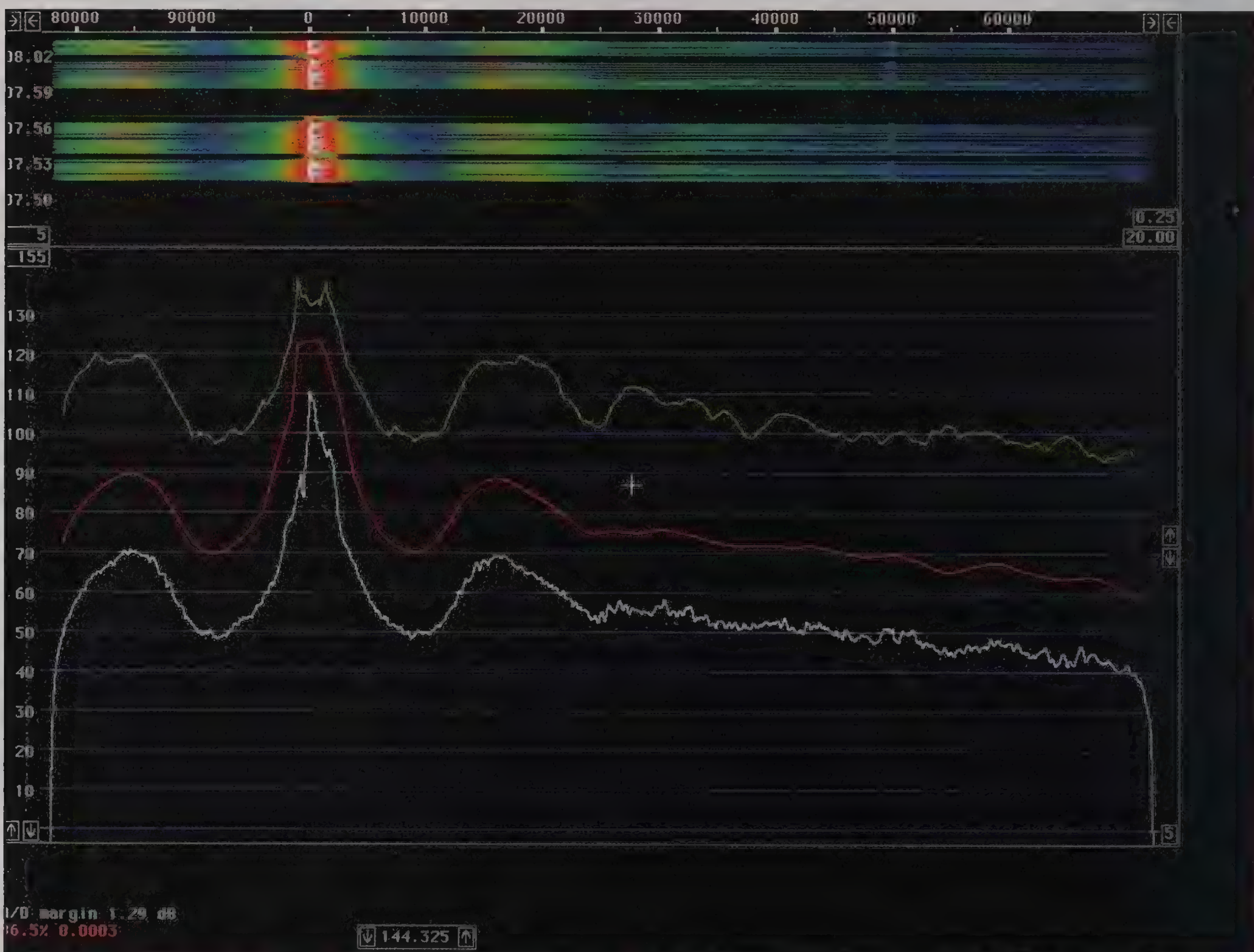

Figure 16. The spectrum of an FT817 in SSB mode on 144 MHz. The splatter is due to an instability of some kind. The signal is clean at voice high levels, like when saying "Aaaaa" into the microphone, and also at low levels. Somewhere in between the splatter is terrible as this image shows. This unit must be regarded as faulty. I do not know how often this kind of error is present in these rigs, but I have seen another one that did not have this error.

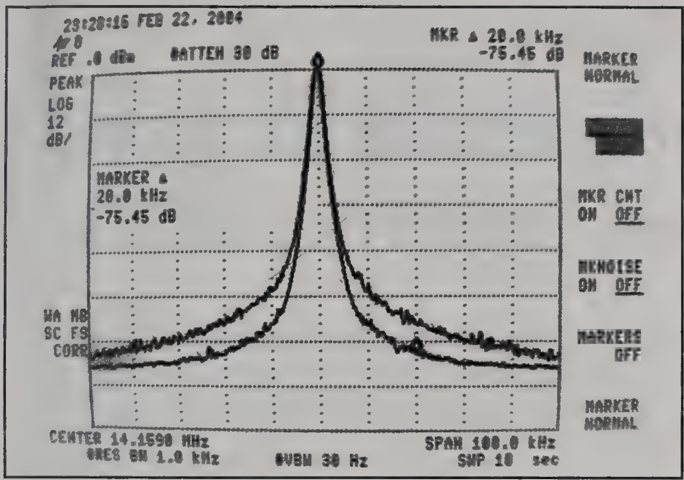

Figure 17. Performance of the HP8591A spectrum analyzer. The upper curve is peak hold and the lower curve is the average-power spectrum. At 20 kHz the average spectrum is 75.45 dB below the carrier, which translates into –101dBc/Hz. The peak-hold spectrum is at about –65 dB with respect to the carrier. Note that the vertical scale is 12 dB per division.

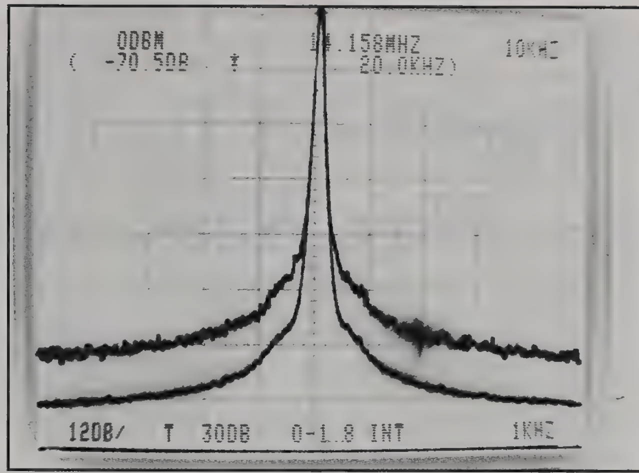

Figure 18. Performance of the TEK2753P spectrum analyzer. The upper curve is peak hold and the lower curve is the average-power spectrum. At 20 kHz the peak-hold spectrum is 70.5 dB below the carrier. The average-power spectrum is 12 dB lower, which translates into –111dBc/Hz. Note that the vertical scale is 12 dB per division.

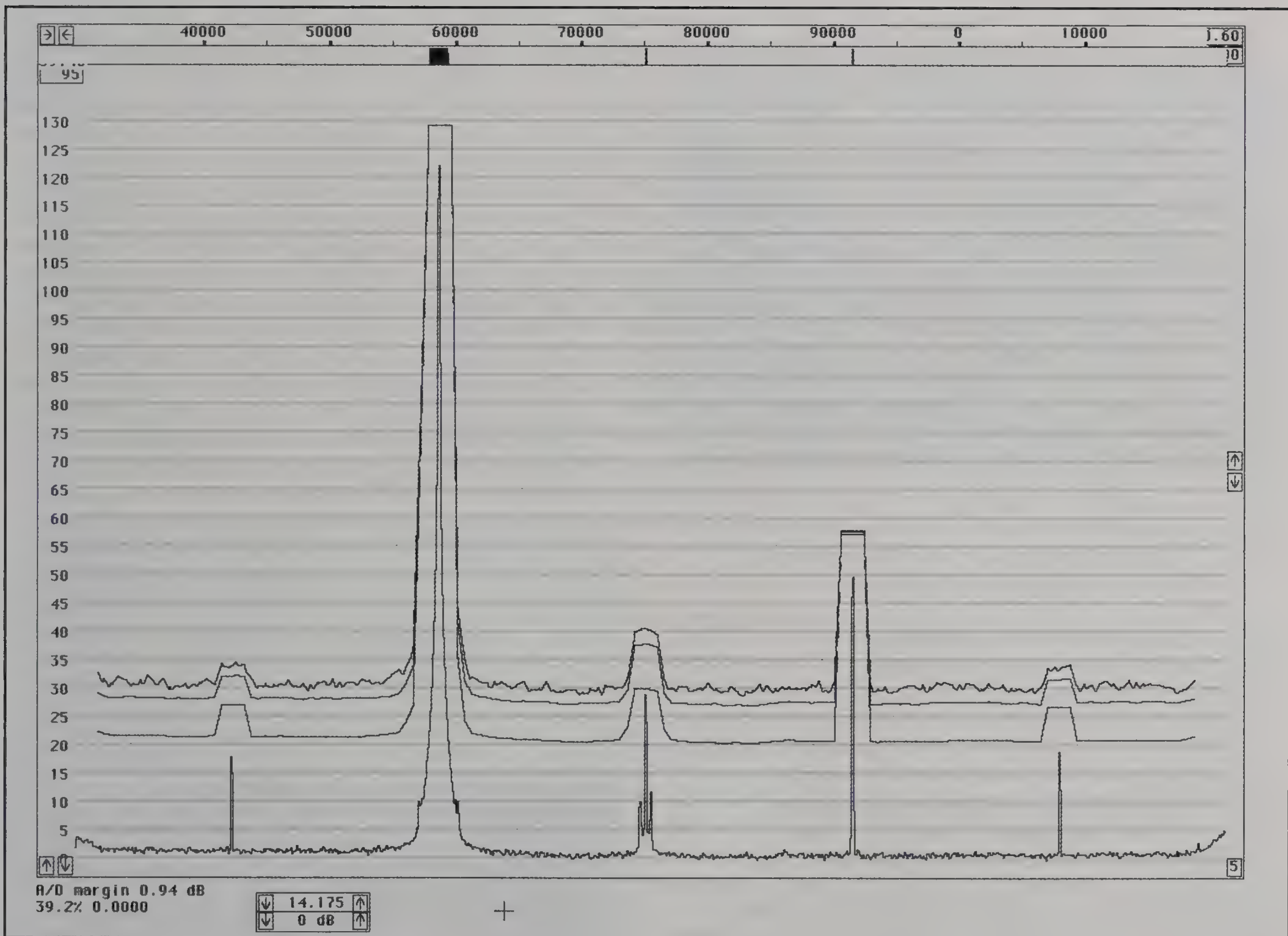

Figure 19. Performance of the WSE converters with Linrad in TX test mode. Counting from the top, the first curve is peak hold, the second is peak power averaged with the equivalent of a 1-second RC time constant, and the third and the fourth are average-power spectra. The first three spectra are at a bandwidth of 2.4 kHz. At 20 kHz the average spectrum is 109 dB below the carrier, which translates into –143 dBc/Hz. Because the system uses direct conversion, the spur at 91 kHz is the mirror image. The spur at 75 kHz is the DC offset and 1/f noise of the Delta44 surrounded by the low-frequency magnetic field from a fan picked up by the Delta44. The spurs at 43 and 107 kHz are due to second harmonics inside the Delta44.

(Continued on page 72)

VHF+ Roving

Part 1 – A Dual Perspective on How, Why, What, When, and Where?!

Operating as a Rover on the VHF+ ham bands is not as simple as it may seem. One aspect of operating has to do with the various techniques used in different geographic areas of the U.S. Here ND2X and N4FLM discuss these techniques.

By Paul S. Goble,* ND2X, and Wayne Gardener,† N4FLM

Rovers have become an important part of the VHF contesting scene. They provide contacts for many fixed stations, as well as other rovers, from grids that otherwise would be barren of activity. While an invaluable asset to the serious contester, there has often been controversy of one kind or another surrounding mobile operation or roving during contests.

ND2X's first roving experience was in the early 1980s, when the rule was to sign "mobile" from vehicle-mounted stations. This first roving station was comprised of a Cushcraft Squalo antenna and an IC-551D (75 watts) on 6 meters; an IC-251A and KLM 160-watt brick, through a splitter to two quarter-wavelength mag mounts, one on either *side* of the Suburban for horizontal polarization; and 25 watts of 440 FM to a two-section collinear vertical whip. This was the family vehicle, complete with family. The second harmonic, NEØM (see March 1984 *QST*, page 54), gave an additional contact to each station worked by ND2X/m.

There was great gnashing of teeth in some quarters over the fact that two contacts from two different callsigns originated from the same station, even though it was clearly in accordance with the "family station and equipment" aspect of the rules. The main concern of most of the complainants was probably generated because WBØDRL, with his superior antenna systems at the time, worked both calls in so many more grids than anyone else as the trip progressed along I-70 eastbound, from Colorado to New Jersey.

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Now there is grid circling, technically legal, but according to many, very questionable on the basis of integrity. There are also captive rovers who can only contact the big-gun station which provides them with the equipment that operates outside normal frequency ranges but within band limits, preventing many others from being able to work them. There are the rules changes or rule-change proposals which come up relatively consistently. There are, no doubt, other controversial issues, but these aspects of roving are beyond the scope of this treatise and will not be discussed. The purpose here is simply to compare and contrast the two main roving modes used in the continental United States.

Discussion

Based on lengthy exchanges/threads in the blogosphere of various amateur radio e-mail reflectors, and discussion with folks at hamfests and ham radio society conferences, it is obvious that many hams do not understand roving. ND2X was once accused by an East Coast ham on one reflector of being the only one in the country to use the run 'n' gun mode. This often-demonstrated lack of understanding is, apparently, because many are unaware of the various parameters that impact roving, of development of the equipment suites and antenna configurations used, and of operating techniques applicable to any given route or portion thereof. It is apparently a mystery to many that roving routes and plans vary due to many external factors, and that these external factors determine which of two primary modes of roving are used. Using military parlance, one is labeled "shoot and scoot" and the other is termed "run and gun."

"Shoot and scoot" is a military term used to describe the operational situation in which an artillery unit sets up and fires from a position for awhile and then packs it all up and moves to a new location and fires from there. This also sums up the contesting rover ideology used in this comparison of the two main roving styles. The shoot 'n' scoot mode rover is a station moving amongst a series of advantageous terrain locations, stopping at each, raising one or more towers with directional high-gain antennas, and operating for a time before packing up and moving to the next point of terrain advantage, sort of like a series of mini Field Days. The emphasis in shoot 'n' scoot roving is to maximize the number of contacts achieved.

"Run and gun" is a term used by the military to describe firing one's weapon while moving, applicable to individual soldiers firing while running, and up echelon to weapon systems such as tanks firing while in motion. In like manner, the run 'n' gun mode rover is a station operating "mobile in motion" for all but an occasional few minutes here and there, *never* changing antenna configuration at any time during the contest from that used while in motion. The emphasis in run 'n' gun roving is to maximize the number of grids activated and therefore the number of unique grid combinations achieved.

Note that the first mode involves radical changes in antenna systems and configuration between that used while in motion and that used while stopped on some terrain vantage point or other. The second mode never alters antenna configuration, from contest start to contest end. Neither type of roving is better or worse than the other; they are simply different. On any rove, as determined by one's chosen route and its geo-political characteristics, a rover might employ either one or a combination of both.

Roving Parameters

As stated, the geo-political characteristics of the route chosen for any given rove determine the roving mode to be employed. Every rove is impacted by a combination of terrain, vegetation, existing roads, infrastructure and traffic, population density and distribution, climate and weather, and area-specific propagation.

Terrain: In general, a roving route can be described in terms of mountains, hills, rolling terrain, or flat, open spaces. Clearly, any significant rove is going to involve a combination of these characteristics. It's easy to visualize the effect of mountains as one drives on almost any interstate in the eastern time zone (north of Florida), looking up hundreds of feet to the top of surrounding terrain while winding along a mountainside through some river valley or other. The same is evident if driving through the Rocky Mountain ranges or the Sierra Nevada mountains.

Continuing with an amazing grasp of the obvious (a little humor here), hills are like mountains except much smaller; rolling terrain is the situation where the road varies up and down in elevation, blocking antennas from the desired propagation path in the low spots; and flat, open spaces are where one has pretty much 360 degrees of being able to see the horizon off in the distance. Photo A is a picture of this last situation. It was taken in Texas, but this same situation is often encountered (and not limited to) the middle third of the continental U.S. and is affectionately known as "miles and miles of miles and miles."

Note that the term "mountaintop" used herein actually refers to any point of terrain advantage. This includes everything from actual mountaintops such as Pike's Peak or Mt. Washington, etc., to much less prominent locations such as bridges that exhibit a "height above average terrain" advantage; examples include the bridge over the Delaware River on Interstate 295 in southern New Jersey or the bridge over the Mississippi River on Interstate 10 in Louisiana. Even getting off at an interstate exit and operating from a shoulder of the associated overpass can provide enough advantage to make the difference between completing a contact and not!

Photo A. Flat, open spaces are where one has pretty much 360 degrees of being able to see the horizon off in the distance. This photo was taken in Texas.

An interesting phenomenon, easily observable if operating while in motion, is presented by the physics of shadowing and diffraction. It is especially evident in rolling terrain. The easiest example to visualize is driving on a road which travels directly away from or directly toward a distant station. While in receive, notice that just after going over a hill that "blocks" said station, the signal virtually disappears. However, as progress is made down the hill, even though proceeding lower in elevation, signal strength slowly increases, peaking again at the top of the next hill. The worst propagation occurs just after disappearing behind any terrain that comes between a mobile station and a distant station. This is due to shadowing. The increase in signal strength as progress downward takes place, away from the initial shadowing point, is due to diffraction. If the mobile station is transmitting, the distant station will notice the same decrease/increase in receive signal strength as that observed by the mobile station.

Photo B. Within the continental U.S., trees are the hindrance most commonly encountered by roving stations, as evidenced by this photo, which was taken in Texas.

Vegetation: The vegetation of primarily concern to rovers is trees. There are other forms of vegetation—e.g., dense hedge rows, large bushes, and the like—but trees are the hindrance most commonly encountered by roving stations within the continental U.S (see photo B).

While roving on I-95 in Maryland, ND2X had no problem making contacts on 50 through 222 MHz, but he noticed a definite decrease in 432-MHz performance and found 1296 MHz to be virtually impossible. Mountaintop stations running respectable power and high-gain antennas could not be heard, nor could the 85-watt mobile signal. The trees densely packed along both sides of the road absorbed so much energy above 432 MHz that communication on those frequencies was virtually impossible.

I-95 in Maryland sports relatively flat (rolling at worst) terrain, but it is lined by these densely-packed trees, all at least 60 feet tall. If surrounded by trees, one must find a way to raise

Photo C. In most of the western portion of the central time zone, most of the trees are in little groups well off the road, planted around houses as wind-breaks.

one's antennas above the treetops to operate successfully at frequencies above 400 MHz. This illustrates why tree size is such a concern to shoot 'n' scoot rovers; they must know how tall their towers must be to clear trees at their selected operating locations. It also matters whether the trees are deciduous or coniferous and what time of year it is; trees with no leaves do not absorb nearly as much RF as their "clothed" cousins!

There are those portions of the continental U.S. that do not present a vegetation problem. The Maryland I-95 example is in direct contrast to most of the western portion of the central time zone, where most of the trees are in little groups well off the road, planted around houses as wind-breaks (photo C). Using the ND2X 23-cm SSB experience again, the best 1296 -MHz DX on the East Coast was from FN20 to the Pack Rats in FN21, while ND2X/M in EM23 worked K5VH in EM00 without difficulty. The difference was not so much terrain as it was vegetation or, more accurately in the latter case, the lack thereof!

Roads, Infrastructure, and Traffic: Roads and highways vary from those (as in New Jersey) which wind through the countryside following old Indian trails, to the arrow-straight miles and miles of miles and miles of roads in the American Great Plains. In between, one finds those which follow the dictates of terrain, as with the interstates that traverse the Appalachians, Ozarks, Catskills, or any other mountain range, such as I-70 west of Denver in the Rocky Mountains. In eastern Tennessee, for example, if driving up I-75 north, one has a pretty good indication what the lay of the land does. It goes up and up and up then down and down and down. Unfortunately, the majority of interstates are routed primarily in and through valleys, as are many of the secondary roads. Roads with tall mountains on both sides and thick roadside foliage 50 feet high or more are the rule rather than the exception. This does not present the most favorable operating conditions for any mobile-in-motion VHF station, to say the least (photo D).

Photo D. Roads with tall mountains on both sides and thick roadside foliage 50 feet high or more are generally the rule rather than the exception. This does not present the most favorable operating conditions for a mobile-in-motion VHF station.

Photo E. This road, with no shoulder, sports a 70-mph speed limit and a great radio horizon!

One will also encounter man-made hindrances to propagation, like those hilltops where the roadbed has been cut out and travels through the resulting man-made gully for anywhere from several tens of feet to significant fractions of a mile. Anyone who has operated mobile through a metropolitan area has traveled roads sandwiched between concrete walls much taller than the height of the mobile antennas. There are also concerns about construction and the delays this could potentially cause either type of rover. As tree height is important to the shoot 'n' scoot rover because of antenna height concerns, type and positioning of roads is important to the run 'n' gun rover. To maximize number of grids activated, one must maximize selection of those roads going north-south that are as close to even-numbered longitude lines as possible. Without going into too much detail at this point, traveling along north-south grid-square boundaries is a good thing for run 'n' gun roving to maximize the number of grids activated for the minimum miles driven. Fortunately, many roads meeting this requirement exist in the Great Plains. The other nice characteristic of this last category of roads is that the speed limit is often at least 70 mph, which helps when one's goal is to cover as much ground as possible. The road shown in photo E, complete with no shoulder, sports a 70-mph speed limit and a great radio horizon!

The Indian trail roads, on the other hand, have low speed limits and are generally to be avoided. Many accesses to the desirable mountaintops do, unfortunately, exhibit many of the characteristics of Indian trails, even if they were built recently, and cannot be avoided if one is in shoot 'n' scoot mode (photo F).

Photo F. Indian trail roads have low speed limits and generally are to be avoided.

Roads between shoot 'n' scoot locations can be vastly different or border on non-existent. At many shoot 'n' scoot locations the last few 100 feet or more of "road" are not much more than a trail. Often there is a steep incline that is either gravel or blacktop that's in bad need of repair. If it's gravel, the turns will exhibit "washboard" and there is no way to go over this type of road, except very slowly. A scary aspect of many blacktop roads is meeting that big truck hauling coal at breakneck speed down the side of the mountain! There are also those "switch back" turns, the ones where the back end of the vehicle passes the front end on the way through the turn. This has a tendency to make passengers motion sick—not a good thing for traveling up or down a mountain, and it's no help when trying to talk the XYL into going along!

From a pure infrastructure perspective, it is necessary to consider fuel consumption and refueling requirements. Nothing ruins the fun any faster than getting out the old magnifying glass and map and sitting in front of the vehicle's headlights at 0230 local in some Podunk town while (1) trying to find your way to someplace you heard was really good, and (2) trying to find a sign that indicates whether the gas station is going to open at all on Sunday, and if so, when. Always fill or top off the tank before heading out to or through remote areas.

There are also considerations of traffic density; we all have roadways we know to avoid at certain times because traffic is so heavy that delays are inevitable. I-35 from 30 miles north of Austin, Texas southward to San Antonio, between 1000 and 2200 local any Sunday is an excellent example, as is the Washington, D.C. beltway any rush hour. Generally speaking, since most long contests are on weekends, rush hour through metropolitan areas is not a concern. Some of the sprint contests might feel the impact, however, since 1900 local start times can still see the effects of rush hour in some areas. Also, extra care is needed if one is traveling an area where the bars close at 0200 local Sunday morning (Saturday night) and you're pushing to get to that next grid or mountaintop!

Population Density/Distribution: The population of the continental U.S. is approximately 291.5 million, distributed as shown in the accompanying map (figure 1). According to ARRL figures, of the roughly 660,000 licensed hams in the U.S., about one third are totally inactive, one third are really active, and another third get on the air sporadically (a little sporadic-*E* lingo there), perhaps for contests and such. Further,

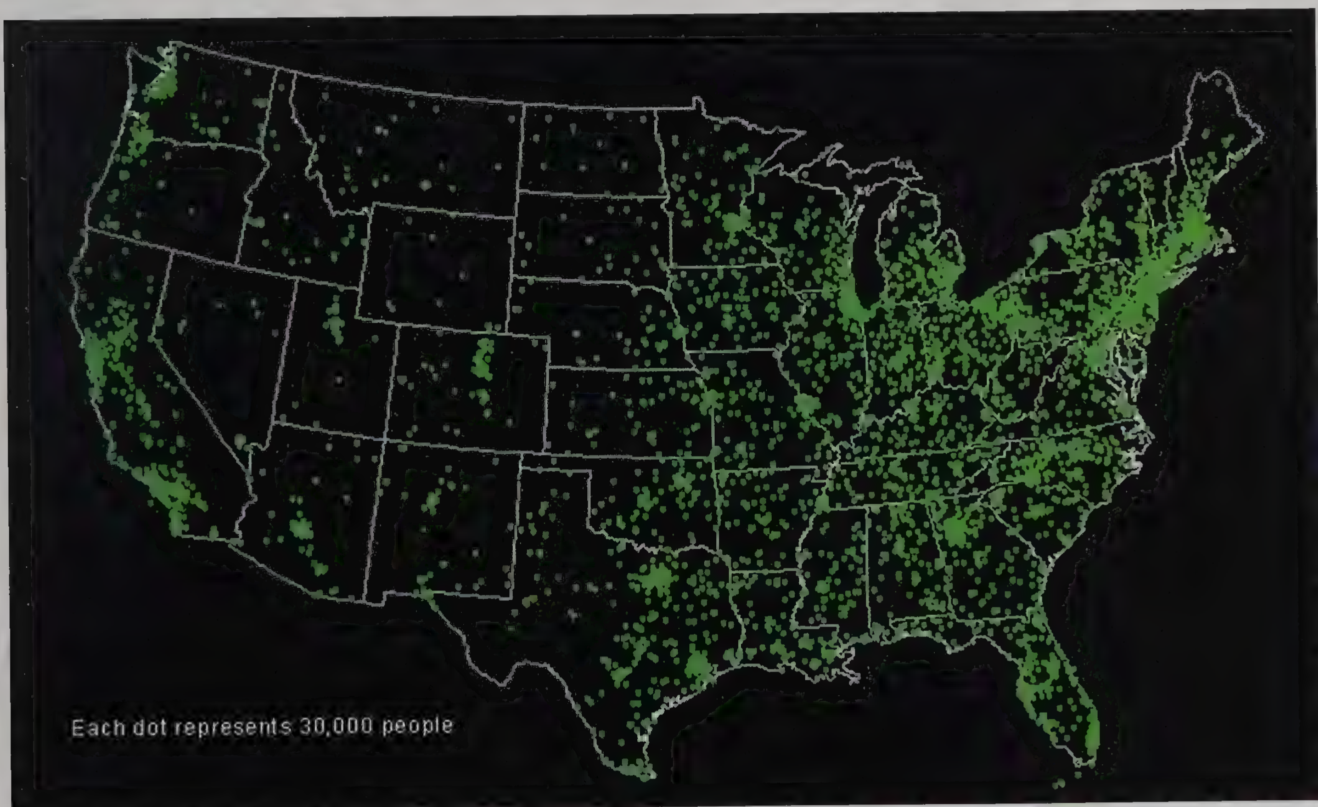

Figure 1. The general distribution of population within the continental U.S. Note that there are just three clearly defined areas of high population density on the West Coast.

about one third of the last two thirds are in any way VHF active. This means, optimistically, that perhaps as many as 146,000 hams nationwide are going to be on the air for at least a portion of any given major VHF contest. This is less than one half of one percent of the general population. The map depicts the general distribution of population within the continental U.S. Note that there are just three clearly defined areas of high population density on the West Coast. Starting from about 97 degrees west longitude and moving eastward, population density picks up, and it can be seen that the eastern third of the nation sports the most major population centers. Further, the northeast quadrant is actually the dominant area for general population density. Note that each dot on the map represents 30,000 folks.

Based on the figures and estimates above, the VHF contesting dilemma, for both fixed and roving stations, can be shown. Assuming uniform VHF-active ham distribution throughout the general population (a *big* stretch), this means, optimistically, that there could be as many as 15 hams who might be on for a portion of a VHF contest anywhere one might find 30,000 population. In most cases, however, this is a *very* optimistic figure. While all these numbers are estimates, and some of the assumptions are questionable, it should be evident that there aren't very many folks on VHF except perhaps in major population centers. In Lubbock, Texas, for example, with a population of almost 200,000, there may be as many as eight hams on during any given VHF contest, and often most or all are operating at the W5LCC club station. In fact, on Sunday morning at 0630 local during the September 2000 ARRL VHF QSO Party, in the area of Omaha, Nebraska, with a population of over 725K, not counting all the suburbs outside the actual city limits, there was nobody on the air! All contacts from that area were from one or two grids away. This rather bleak picture is an excellent illustration of why many fixed stations find rovers such a valuable asset during contests!

Even if the most optimistic scenario of all the above assumptions and estimates were to be true, it is a fact that in nearly two thirds of continental U.S. one would run out of folks to contact well before one would run out of contest. An aspect of roving in these portions of the country is that as one runs out of stations to contact, one moves on to another area with more, new stations to log.

An additional aspect of population density is that there are significant areas of the continental U.S. in which almost everyone goes to bed by 2230–2300 local on Saturday night. For the run 'n' gun rover, this can cost up to eight hours of no contacts, severely limiting final grid count. ND2X arranged with VHF amateurs along the route to stay up during the wee hours of Saturday night to give contacts from approximately 2300 to 0600 local time Sunday morning, at which time they became too far away to hear. It turns out that the assumption that there would be activity in the Omaha area at that time of the morning was erroneous. If there is a next time, arrangements will be made for at least 2230 local time Saturday night to 0730 local time Sunday morning!

Climate and Weather: Heat, cold, precipitation, wind, and almost any other meteorological factor one can imagine impact roving and choice of roving routes. Many mountaintops are not accessible in the winter. Forget Pike's Peak most years from early October through late April, for example, because the snow prevents access to the top of the mountain. Mt. Washington can be a challenge because of wind from time to time, even without precipitation. Ice and snow are clearly potential show stoppers in the winter months for anywhere above the Mason-Dixon line (roughly 39°43' 22" N) or at higher elevations. Many times this limits travel to interstates and other major routes that are well and quickly cleared of snow or kept relatively clear of ice with chemicals. In the best situations, it can slow travel significantly.

If roving through the southernmost states from June through September inclusive, air conditioning is an absolute must, not only to keep the operator from dripping all over the equipment, but to keep the equipment within permissible operating temperature limits. This is especially the case during daylight hours with sun beating down on the vehicle, but if the temperature is 85 degrees or more at 2230 local time, as it often is in San Antonio and points south during the summer, it's important at night, too. Generally speaking, the best month for rovers covering a wide area is September, when it's generally not to hot nor too cold. It's more or less between the hottest of the summer and the coldest of the winter, and weather impact generally will be minimal. There are always exceptions—"your mileage may vary"!

Special "Area-Specific" Propagation: As the story goes, "There I was, on my way to Southeast VHF Conference at the end of April 2003, working into Florida from the mobile on three bands from 144 MHz to 432 MHz, traveling 72 mph on I-30 through EM23 in northeast Texas." It was the start of that year's spring tropo season which graces the southeast U.S. every year. Propagation across Lake Michigan, with the population centers surrounding the lake shores; the California-Hawaii VHF ducting which has been so well documented; and the fair possibility of aurora in the far northern states are all examples of area-specific propagation. Okay, so San Antonio had aurora once, in August of 1987, but it's not something that is at all likely. It's not that these modes don't occur anywhere except as mentioned; it's that some areas exhibit periodic tendencies to perform. The spring tropo in the southeast continental U.S. is pretty reliable, late April through early June, and it is always hoped that it will extend into June far enough to support the ARRL contest; sometimes it does. What fun!

(to be continued)

Back-Up Power Switching For Home and Repeater Applications

What happens when we lose power at our home QTH? Usually we are off the air. Here WB9YBM provides a simple solution to the problems faced by a loss of power.

By Klaus Spies,* WB9YBM

We have seen the benefits that uninterruptible power sources provide for our computers during glitches or outages from the power company. The same benefits can be of use to the amateur community to allow for emergency communications during power outages. In keeping with the make-it-ourselves attitude (and frugality, for some) of the Amateur Service, here's a way we ourselves can make a back-up power source.

In the early days, any switching done for high-voltage or high-current applications was done by relays or solenoids. In some applications this may still be the safest approach; with few modifications the following circuits can be adapted to use relays. Our main focus here will be diode switching, since diodes are much faster and therefore less likely than relays to cause transient glitches during the switching process. In the modern microprocessor-based equipment, which seems to be more sensitive to power purity than older equipment, clean power is certainly more of an issue, so our focus here will be on diode switching.

Parts numbers in the following circuits are intentionally not specified, as they are specific to the current requirements of each user's application. While it may be tempting to use, let's say, a diode capable of a maximum current of seven amperes because the fuse of our equipment is rated for that amount (or the equipment is rated for a maximum current draw of that amount), in-rush current during equipment turn-on must be considered as well—which is why typically even fast-blow fuses don't open until approximately twice their rated current is exceeded. On the other hand, if all you're building is a switch for back-up power to your hand-held transceiver, a diode the size of your lunch box is definitely overkill! On another cautionary note, if a diode is designed to be mounted to a heat sink, it is highly recommended that this feature be utilized. The diode might keep working inside your air-conditioned house with no problem. However, if you're operating mobile or portable in the middle of the hottest summer day in your area, you should not have to worry about equipment failure.

Figure 1 shows a basic diode switch circuit, using a battery as a back-up. The resistor, "R," is included to trickle charge the battery during normal operation. You will need to refer to the battery's data sheet to calculate the proper value. If you can find convenient meters at a hamfest, you can even include current and voltage meters to show the status of your battery, but these are optional.

For proper charging, there must be a positive voltage difference between the input and the battery voltage.

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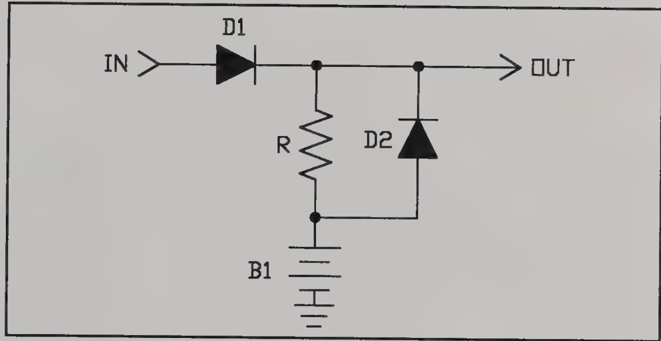

Figure 1. A basic diode switch circuit using a battery as a back-up.

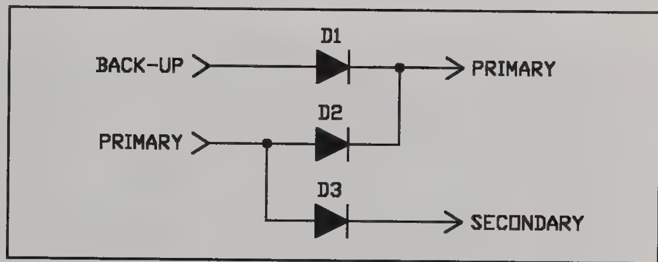

Figure 2. By adding a third diode, the longevity of the back-up power source can be extended without increasing the size of the back-up supply.

If extended operation is expected, or if power demands exceed the short-term capabilities or long-term capacity of the back-up power source, the longevity of the back-up power source can be extended without the necessity of increasing the size of the back-up supply to levels that might not be affordable or practical. This can be accomplished simply by adding a third diode, as shown in figure 2. Figure 2 is very similar to a concept that is already in use in many vehicles; this is how electrical equipment, such as car clocks, are wired. For clarity, the recharge resistor has been omitted here, but it can be added as shown in figure 1.

The primary output is used to power the primary equipment—transceivers in the hamshack, transmitters, receivers, and control circuitry in a repeater, etc.—while the secondary output powers the less important accessories, such as amplifiers, spare receivers, and other devices not vital to the basic operation of the station or repeater. When the primary power source cuts out, only the more vital primary devices will retain power. In an emergency involving a power outage, a QRP repeater is better than no repeater at all! ■

Grid Locators Are Not Squares

An accident in history at the Central Staes VHF Society's conference in 1981 caused some confusion about the society's grid locator award. The award called for identifying one degree by one degree "squares," and the term squares stuck and carried forward into the Maidenhead Grid Locator Program. Here W3EP explains why a grid locator is not a grid square.

By Emil Pocock,* W3EP

The familiar grid locator system just had its 25th birthday. It was proposed by European VHF managers at a meeting held in Maidenhead (near London) in 1980 and quickly spread around the world. Maidenhead grid locators are used extensively on the VHF bands and higher and have some limited applications on the HF bands. Grid locators are the basis of multipliers in some contests and several awards, most notably the ARRL VHF-UHF Century Club (VUCC), which began in 1983.

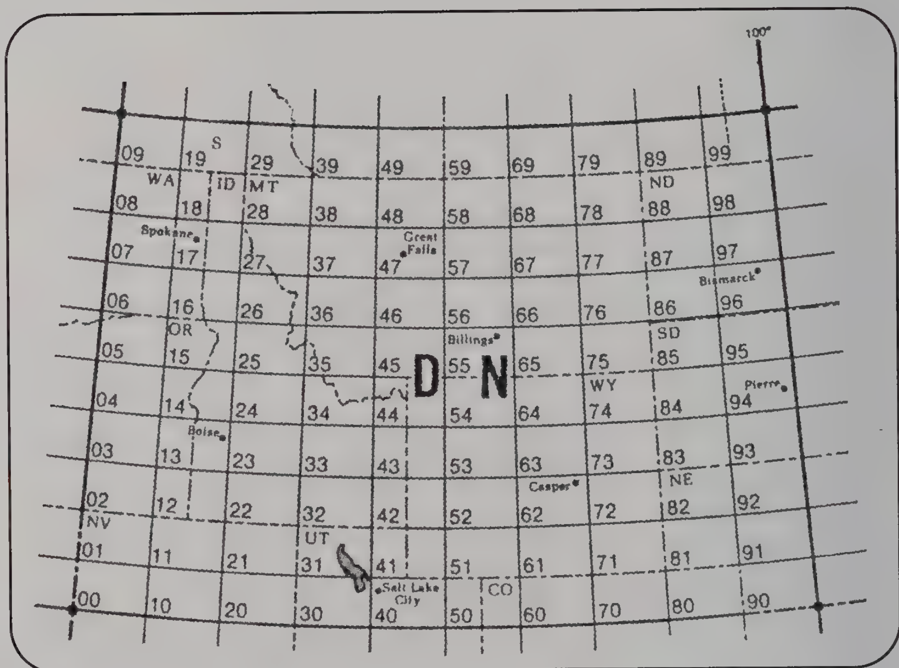

Figure 1. The grid locator field DN includes all of Idaho, Montana, Wyoming, and parts of adjacent states and provinces.

What Are Grid Locators?

Grid locators are shorthand ways of referring to discrete areas on the Earth precisely 2 degrees longitude wide (east-west) and 1 degree latitude tall (north-south). Each locator is identified by a unique combination of two letters and two numbers. Each two-letter combination indicates a particular field that measures 10 degrees latitude by 20 degrees longitude and contains 100 locators. Individual grid locators within each field are numbered from 00 to 99, beginning in the southwestern corner. Figure 1 shows a typical field. As it takes 324 fields to cover the globe, corresponding to the letter combinations AA through RR, it is easy to calculate that the Earth in its entirety is covered by 32,400 unique grid locators.

A typical grid locator in the center of the United States is about 170 km (107 miles or so) wide and 111 km (69 miles) tall (see figure 2). This is a rather large piece of land to pinpoint the location of a specific station, so grids can be further divided into 576 sub-locators, each of which is 5.0 minutes of longitude wide and 2.5 minutes of latitude tall. Sub-locators are designated by two lower-case letters. The full six-place locator for Lebanon, Connecticut, for example, is FN31vp. Sub-locators are sufficient to place a station in the mid-section of the United States with an accuracy of about 4.3 km (3 miles more or less), as shown in figure 3.

Sizes and Shapes

Now here is the tricky part. Although every grid locator is precisely 2 degrees wide by 1 degree tall, grids have different sizes and shapes, depending on where they are on the Earth. Most astonishingly, not a single grid locator anywhere in the world is a square, although a few (360 to be precise) come close. To be perfectly accurate, not a single grid locator is a rectangle either, although most locators more closely resemble trapezoids than any other shape. The confusion arises from viewing grids on flat Mercator-projection maps, which show latitudes and longitudes as parallel lines and thus all grid locators as equal-size rectangles (see figure 4).

In actuality, the north-south lines of longitude, which form the sides of all grid locators, are curved and converge at both poles. This prevents grid locators from being true rectangles, which are four-sided figures with interior 90-degree angles and parallel sides of the same length. Grid locators (well, most grid locators, as you shall soon see) do have four sides, but only the top and bottom are

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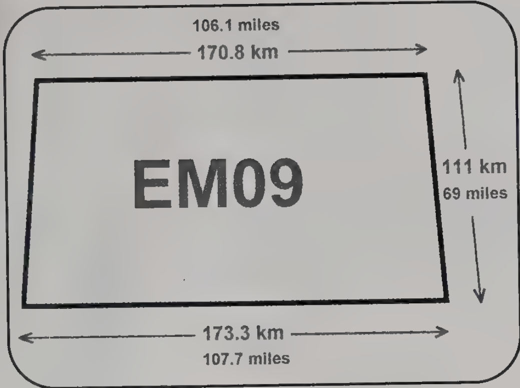

Figure 2. EM09 (Kansas), a typical grid in the center part of the United States, is roughly 107 miles east-west and 69 miles north-south. The top and bottom (along lines of latitude) are parallel, but of different lengths. The sides (along alternate lines of longitude) are actually curved.

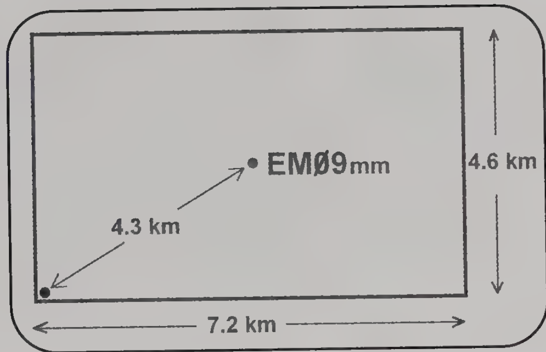

Figure 3. Six-place locator EM09mm (in the middle of the grid) is roughly 4.5 miles wide by 3 miles tall. The actual location of a station within this subgrid could be as great as 4.3 km from the center. Therefore, the distance error between two stations in the mid-section of the country using six-place grid locators could be as much as 8.6 km (5.6 miles).

parallel. The sides bend toward the north, making the tops of grid locators shorter than their bases. Take a close look at figure 2 again. Since the top of one grid locator is the base of the one immediately above it, grid locators are also different shapes and sizes. (This is all true only in the Northern Hemisphere; everything is reversed south of the equator.) Sinuosoidal map projections, like the one in figure 5, show this more accurately.

There are 180 distinctly shaped grid locators and 180 of each variety. They can be divided into four basic different types, as shown in figure 6. Squat rectangle-like locators, which are wider than they are tall, are the most common and account for 21,240 of the 32,400 total. They can be found between the equator and 59 degrees north and south latitude, which includes the heavily populated tropical and temperate zones of the world. Next comes a single row of 180 square-like locators in each

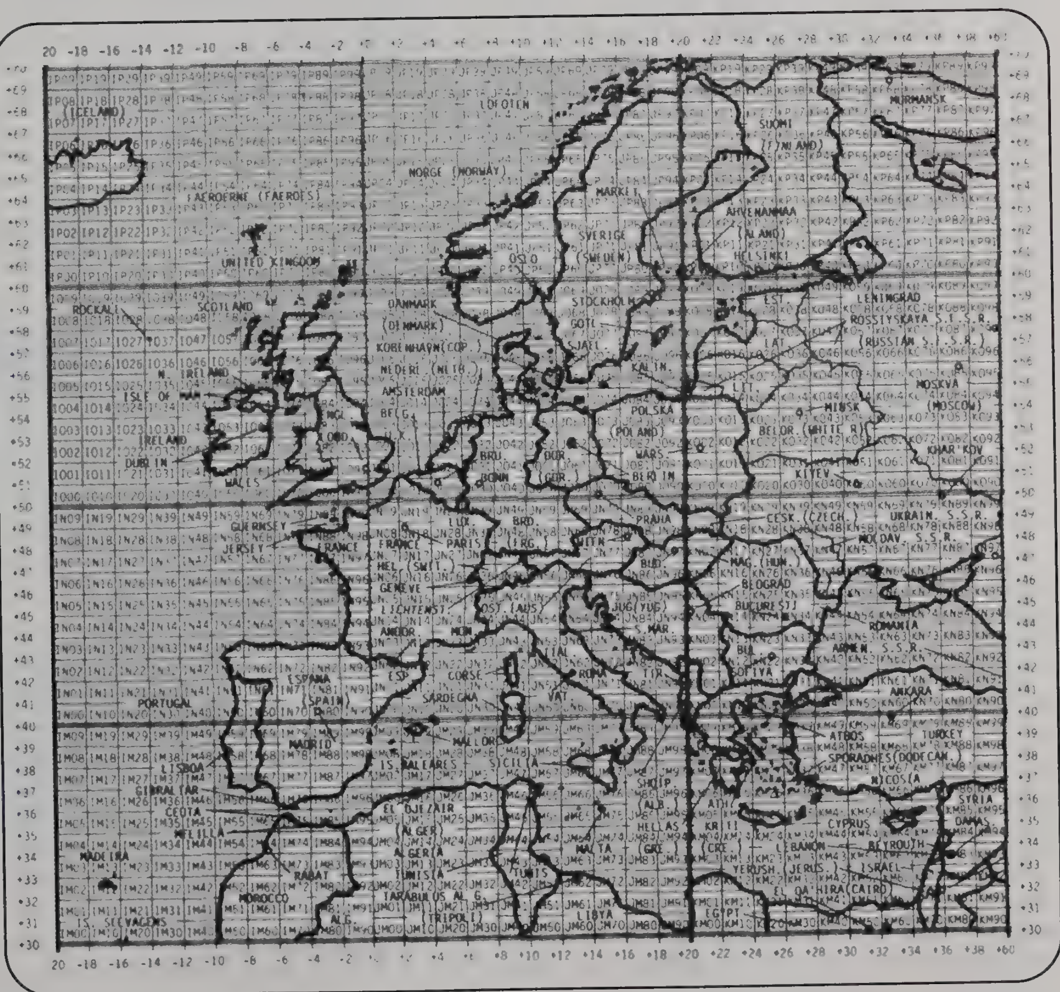

Figure 4. A flat Mercator map projection of Europe, showing 12 fields, gives the impression that all grids are rectangles of the same size. This is a convenient way to show grids, but this kind of map distorts actual sizes and shapes.

hemisphere whose heights are about the same as their average widths. In North America they are strung across Canada just south of the Yukon and Northwest territories. Beyond the square-like grids are 10,440 tall rectangle-like grids whose heights are greater than their widths. Finally, the 180 locators that encircle each pole look more like triangles, because they have only three sides, with common apexes that form the poles.

The area of grid locators vary with their shapes. Grids closer to the equator are larger than those farther away. This is easy to visualize, because all locators have the same north-south height, but their widths shrink with distance from the equator. The largest locators at the equator have bases that are 222 km wide, while the triangle-like grids at the poles have bases that are a mere 3.9 km wide. Grid locators at the equator are thus 100 times as large as those at the poles, with all the others somewhere in between.

Location Matters

Size differences can be significant, even within the United States and adjacent Canada. See the representative grids in figure 7. Grid EL95 (Florida) has a base 201 km wide, in contrast

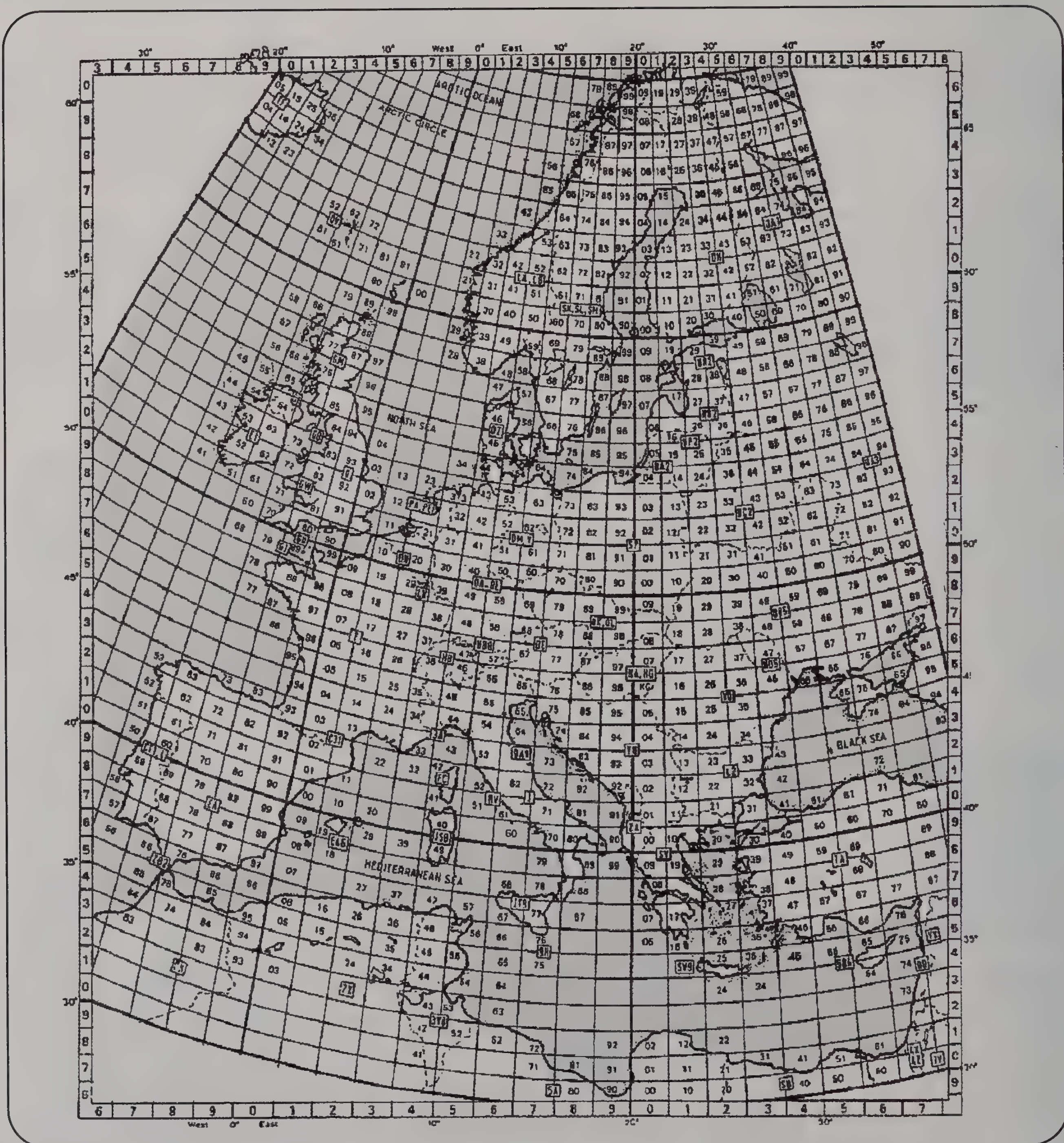

Figure 5. A sinusoidal map projection of the same area of Europe (with two of the most southerly fields truncated) more accurately preserves the sizes and shapes of grids. Compare grids in the southern part of the map with those in the north.

Type	Description	Number of grids
	Northern Hemisphere	
	Triangle-like at the North Pole	180
	Rectangle-like, taller than wide 60—89° (29 unique sizes)	5,220
	Square-like 59—60°	180
	Rectangle-like, wider than tall 0—59° (59 unique sizes)	10,620
Equator		
	Rectangle-like, wider than tall 0—59° (59 unique sizes)	10,620
	Square-like 59—60°	180
	Rectangle-like, taller than wide 60—89° (29 unique sizes)	5,220
	Triangle-like at the South Pole	180
	Southern Hemisphere	
	Total	32,400

Figure 6. The 180 distinct sizes and shapes of grid locators (90 in each hemisphere) can be categorized into four basic types.

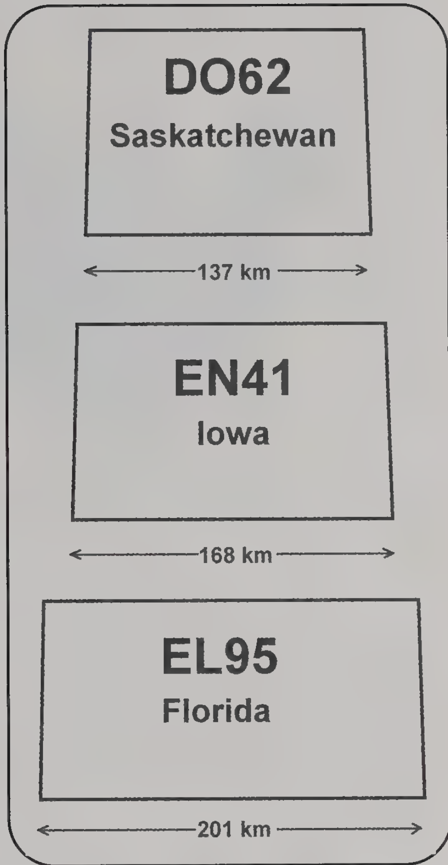

Figure 7. Representative grid locators in the U.S. and Canada are different shapes and sizes. All grids are 111 km (69 miles) north to south, but may have different widths.

to DO62 (Saskatchewan), which is just 137 km wide at its base and has a much smaller area. EM09 (Kansas) lies about midway between these two. Differences in grid sizes are more dramatic for places separated by larger north-south distances. Take a look at figure 8. Tropical Honduras overlaps 11 grid locators, but sub-arctic Iceland, which covers about the same land area, includes parts of 22 locators.

It follows that the distances between grid locators are also shorter where grid locators are smaller. This can make a significant difference on the microwave bands and has implications for other activities. For example, there are more grid locators within single-hop sporadic-*E* range (about 2,200 km) in Europe than in the United States, because European locators are smaller on average.

Work All Grid Locators

Collecting grid locators, whether as multipliers in a contest or as a lifetime achievement, has become an obsession among many VHF operators. VUCC endorsement levels are nearly without end, in contrast to awards based on states, DXCC entities, or even U.S. counties. During the more than 20 years since the VUCC program has been in existence, a few stations have confirmed 1000 grid locators on 6 meters, the most for any VHF band. That is an exceptional achievement, but it is still a long way from working all 32,400 locators. That is undoubtedly impossible within a single lifetime. The number of locators is just too large and there are other practical difficulties.

The number of workable grids can be pared down to something more manageable. Just 13,164 grid locators of the 32,400 total contain land, even if just an island. Further excluding Arctic and Antarctic locators, on the assumption that most are uninhabited or have only few permanent residents, leaves about 9750 locators. Of those remaining, probably no more than 5000 have significant population and any radio amateurs. Of course, maritime mobile stations and expeditions to uninhabited places can make it possible to contact stations in otherwise impossible grids, but this exercise at least puts the problem into a more reasonable perspective. Still, 5000 locators may be too lofty an ambition even for a lifetime of on-the-air activity.

There are more practical goals that are both challenging and attainable. It is possible to work all 100 grids in some heavily populated fields. A few operators have already tallied all the grids in the EM and EN fields on 6 meters and probably on 2 meters as well. The same might be accomplished for field JN in Europe and perhaps other fields. Making contact with stations in all the grids within the various U.S. states and many individual countries is also attainable. Just 17 grids will do the trick for a mid-size state such as Missouri, for example, while 50 grids are required for Texas. Many 6-meter operators, including a few in the U.S. and Canada, have worked all of the 22 locators that touch some part of England and

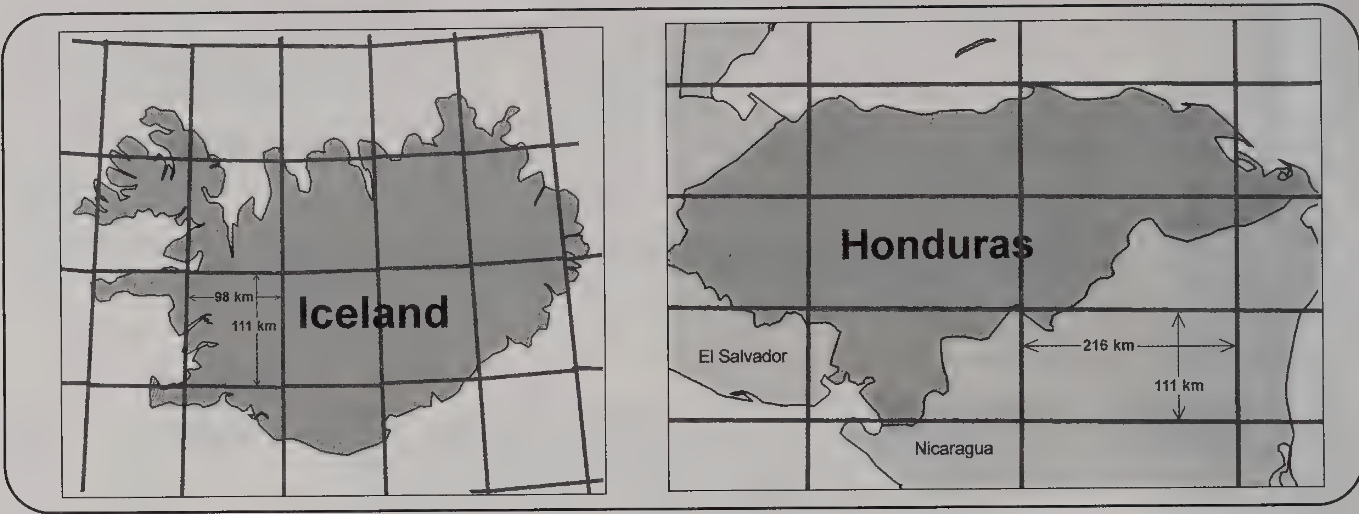

Figure 8. Iceland (39,699 square miles) includes twice as many grid locators as Honduras (43,433 square miles), even though the two countries are about the same size.

the 35 locators that cover Germany, to take some examples from European countries. Europeans have done so on several VHF bands. There are many other such possibilities.

A more lofty project and still within the realm of possibility is to work all of the 488 grid locators that touch some part of the continental 48 states (shown in figure 9). W5FF accomplished this some years ago on 6 meters from New Mexico, but he is the only one so far. Several of these locators contain only small bits of U.S. territory, counting off-shore islands. DM02 makes the list because San Clemente Island, adjacent to the southern California coast, is in that locator. FN25 includes a tiny portion of Moses Island in the St. Lawrence River, which puts it just within the United States. A small bit of DL89 intrudes into Big Bend National Park, but that piece

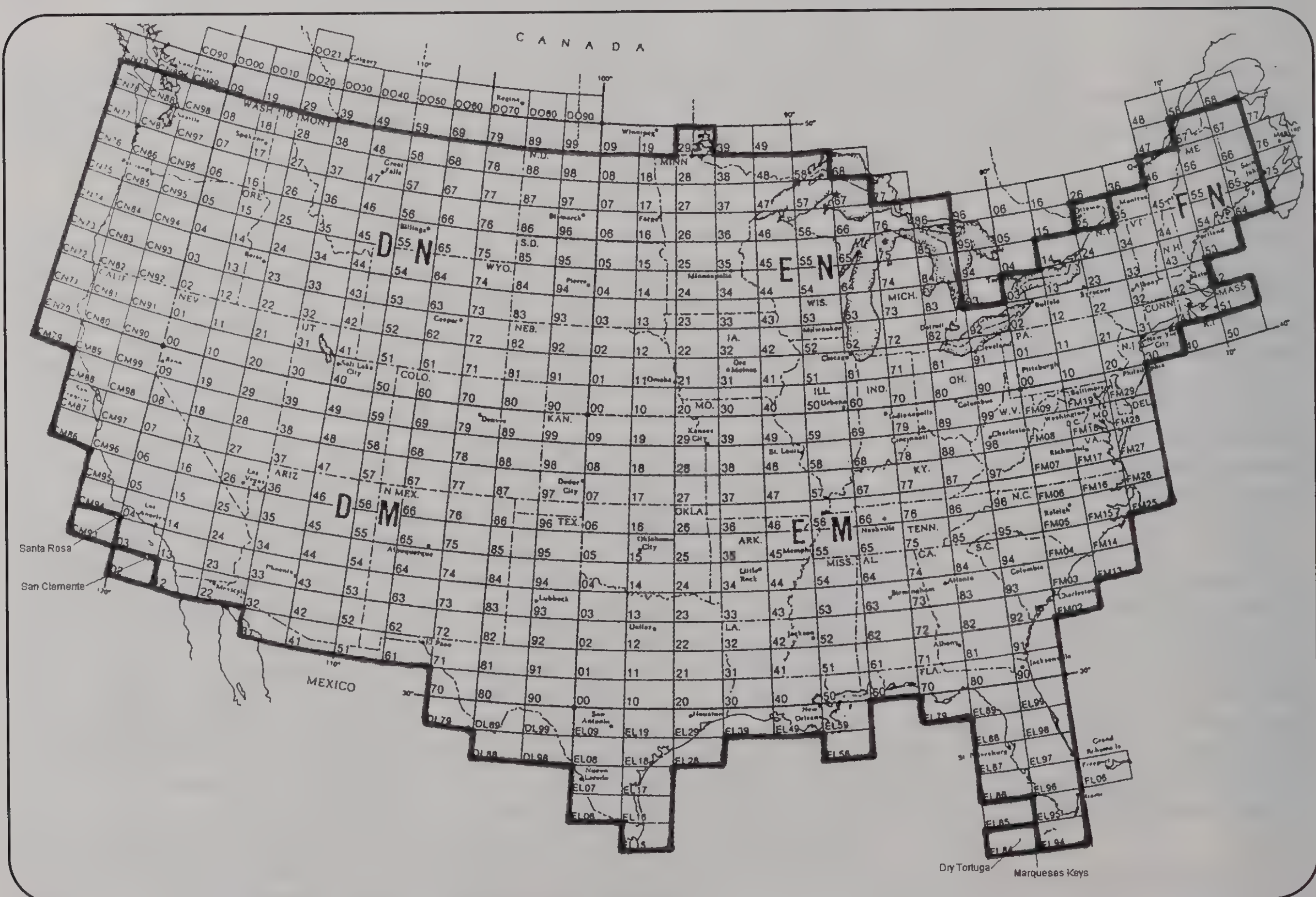

Figure 9. The 488 grid locators of the continental 48 United States. Grids CM93, DN02, EL94, and FN25 are not accessible by land from the rest of the country.

of U.S. territory does not have road access. There are other such curiosities along the borders and coasts of the U.S. You will have to decide for yourself whether to count a locator that touches the United States if the station worked is actually maritime mobile or located in Canada or Mexico.

Working the grid locators in all 50 states boosts the challenge significantly. Hawaii adds 20 locators, but half of them encompass outlying islands with small populations, if any inhabitants at all. About 236 grid locators include some part of Alaska, including the Aleutian Islands, but most do not have resident radio amateurs. This raises the total number of locators for all 50 states to at least 744 (there is some uncertainty about the exact number in Alaska). The total number of grid locators in Canada also exceeds 700, and the majority of Canadian grids are sparsely settled as well.

If you want to accumulate grids in a big hurry, go with a friend and some hand-helds to the North Pole. While your companion makes contacts with you as he or she walks in a circle from grid to grid around the pole, you can tally locators at an astonishing rate and earn several VUCC awards in an hour or so. Figure 10 shows all 180 grids at the North Pole. It will be quite clear from that vantage point that grid locators assuredly are not squares.

My thanks to Curt Roseman, K9AKS (EN41sl), for his help in this project and to those who first heard this article as a presentation at the Central States VHF Conference in Des Moines, Iowa (July 1999), the Mid-Atlantic VHF Conference in Philadelphia, Pennsylvania (October 2001), and the Eastern VHF/ UHF Society Conference in Enfield, Connecticut (October 2002). ■

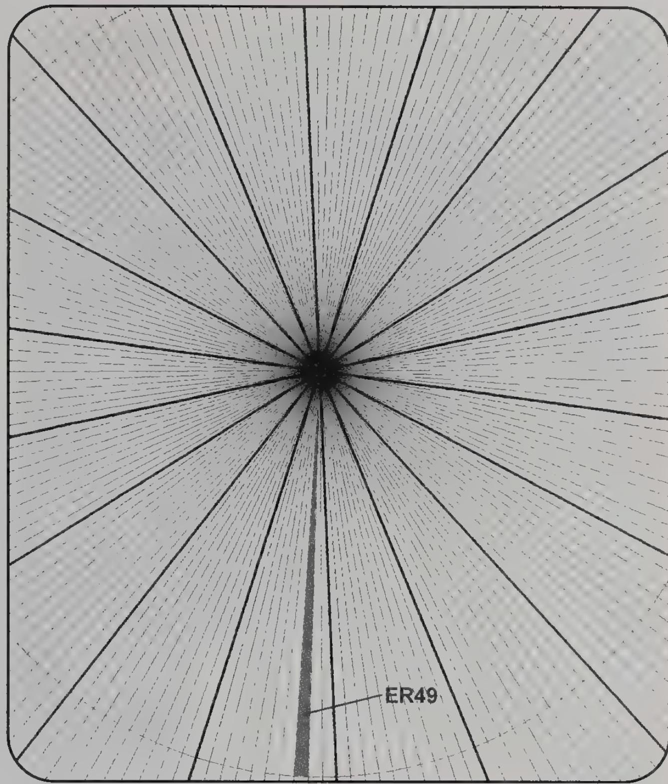

Figure 10. The 180 grids at the North Pole converge. Each polar grid has a 3.9 km base and 111 km sides (2.4 miles by 69 miles). ER49 is due north of Moline, Illinois.

By Joe Moell,* KØOV

Radio Direction Finding for Fun and Public Service

The Watertown Sodalis Squad An RDF Adventure

"It really was the ultimate experience, better than the Grand Canyon, Yellowstone, whale watching, and all the places I've been to!" That's how Pat Browns, WN8Z, of Syracuse, New York described his four weeks of intense radio direction finding (RDF).

The saga began in January, when I received e-mail from Carl Herzog, AB2SI. Carl got his first ham ticket as an RF design engineer about 20 years ago. His antenna designs are used on field-strength measurement equipment for interference certifications. Now his employer is the New York State Department of Environmental Conservation (NYSDEC). "I was doing some wildlife work in my spare time and taking independent study courses," he says. "It was a lot of fun, so I made the switch and now it's like being on vacation every day."

The Watertown Sodalis Squad. Left to right are Bill Kitchen; Pat Browns, WN8Z; Kevin Shannon, WA2ISC; and Dave Aitcheson, KB3EFS. (All photos by WN8Z)

Carl's agency was preparing for two radio-tracking projects to take place from mid-April to mid-May. He and others would attach VHF transmitters to Indiana Bats (*myotis sodalis*), an endangered species,[1] as they left the caves in which they had been hibernating. The goal was to find their summer habitat out on the landscape. Both projects would be happening simultaneously and he needed volunteers to help with radio tracking. One site would be near Watertown, at the eastern end of Lake Ontario. The other would be near Kingston, between the Hudson River and the Catskills.

Previous research suggested that the bats might fly anywhere within 300 miles, but probably less than 50 miles. "Sodalis do not limit themselves to wilderness," Carl wrote. "They are often found in farm country or even suburban areas. The 300-mile radius includes southern Ontario and Quebec; bats know nothing about national borders."

In my previous experiences with migratory bird studies, it was good to have a large number of participating hams scattered over a very wide area. Just being able to hear and log the tags was sufficient to help the researchers. However, these bats were not flying cross-continent and exact locations would be important. What Carl needed was a team of intrepid trackers who were willing to scour the countryside. I posted Carl's request on my website and hyped it on Amateur Radio Newsline and other ham news outlets. I was disappointed when I didn't get many replies, but I discovered later that Carl had gotten all the help he needed, both from stay-at-home hams and those who would go out in the wild.

"We ended up with a total of five new field workers," AB2SI told me. "Three of them were on the project full time. They heard about it through your site and called my office to volunteer. When I found out that all of them knew radio propagation and had done a significant amount of RDF, I thought it would be a good match. We had some extra funding and we were able to hire them for the study."

Since Carl's office in Albany is a considerable distance from Watertown, it was difficult for the regular staff to work at the site for long periods. Having volunteers doing the ground work was a big plus. "It was as easy as you could imagine from my point of view," he says. "These people needed hardly any training."

WN8Z was among the first to respond to AB2SI's request. After working in two-way radio and paging since the late 1970s, Pat retired in 1998 to travel the USA in a motorhome. On his last 30-month trip, he had followed the postings about tracking owls and other critters on my website and on the Biotrackers mailing list.[2]

"I never got into any organized ham radio RDF contests, but this has to be the ultimate foxhunt," Pat told me. "The first week was chaotic and we newbies had no idea what was going to happen when

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Learning Bat Behavior with RDF

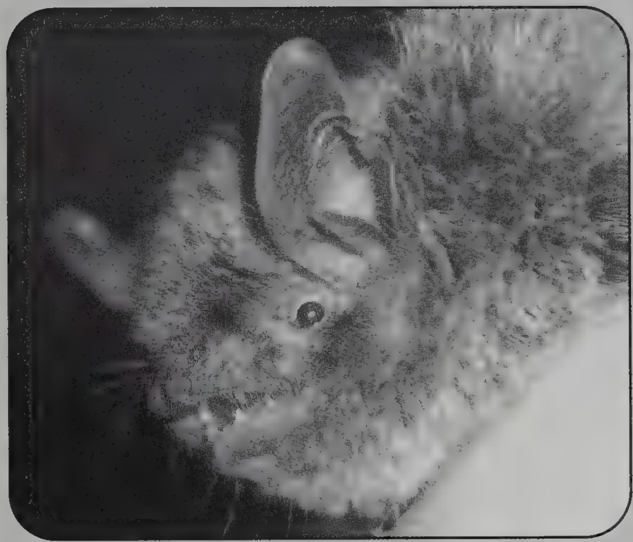
Out of 45 bat species in the USA, about one third are either threatened or endangered. There are millions of bats in New York State, but the number of Indiana Bats is only between 30,000 and 35,000. *Myotis sodalis* is the only federally-listed endangered bat in the state. The worldwide population for this species has declined drastically since the 1960s, dropping from about 800,000 down to about 300,000.

According to AB2SI, "Most other mammal species have been researched to a very significant extent, but bat biology is so difficult to study that there are basic questions we don't yet know the answers to. It's only been in recent years that we've been able to get transmitters small enough to put on them so we can use radio tracking as a tool."

In other parts of the country bats spend time underground year-round. In New York the cave bats only spend the winter there. At present there are only nine caves and mines in the entire state where Indiana Bats do that. Research indicates that this is because the bats are limited in the temperature range that they can tolerate during hibernation; most caves are too hot or too cold.

Sodalis must be relatively undisturbed throughout the winter. If cave explorers were to wake them, even for a short time, they would use up their stored food resources and perhaps not last through the winter. This is not an issue in New York, because the sites are gated or on private property with no access for the public. That may explain why the New York population loss is not as great as it is elsewhere.

Another hypothesis is that bats are losing habitat that they need in the summertime to survive. The Sodalis crew helps researchers study that summer habitat, including the kinds of trees and the area around the trees. "It seems that they can actually be near a fair amount of development," AB2SI reports. "Many of the big dead or dying trees in which we find bats are right on the edge of people's back yards in the suburbs. They also like the living shag-bark hickory, because its bark has a peeling characteristic even on a healthy tree. They like to climb up under the bark."



An Indiana Bat. (Photo courtesy of Carl, AB2SI)

those bats were released. However, the internet is great, and with the studying I did, the posts on your web page, and the talks with Carl, we went packed and ready to go. We had tents, sleeping bags, and even an air mattress in the back of my Geo. We had no clue where we were going to end up."

Others in the Watertown Sodalis Squad, as they called themselves, were Kevin Shannon, WA2ISC, Dave Aitcheson, KB3EFS, and Bill Kitchen. Pat had high praise for them all. "Although Bill has no amateur radio experience, he has tracked moose for the Conservation Department and really has a knack for this," he says.

Snatch, Attach, and Dispatch

The Watertown bats were expected to emerge from hibernation in large numbers around April 15. The team would be ready to net about 30 females, glue on half-ounce radio transmitters, and then try to follow them to the trees where they would form maternal colonies and bear their young. Fortunately, the weather was good and everyone was in shirtsleeves.

"We hams didn't have a clue what we were getting into," relates Pat. "When Carl called and invited us to the tagging operation, his game plan was for us to program the wildlife receivers, make sure their scan worked, and verify that each one heard the tag signals. But we got right in there, helping hold the bats and attach the transmitters. It was obvious that we weren't just there to track, we were getting closely involved."

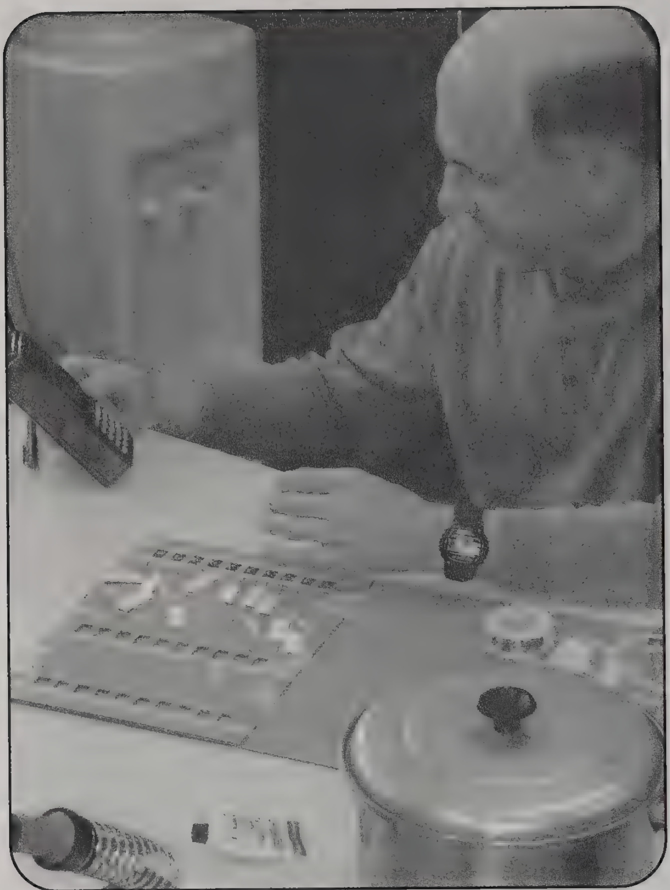
For maximum signal-to-noise performance, professional wildlife tracking receivers such as the R-1000 by Communications Specialists of Orange, California[3] are narrowband (about 2 kHz bandwidth). The Watertown study transmitters were specified to be on six different frequencies between 150.0 and 150.8 MHz for most efficient scanning. Due to minor variations in the individual tags, it was important to verify that the bandpass of the six programmed frequencies in each receiver would encompass all of the actual tag frequencies.

"It was quite an experience under time pressure," AB2SI explains, "because we had the bats in our hands at the moment. You can't check the exact frequency until you've actually glued the transmitter to the bat, because the body capacitance of the animal shifts the tag frequency on the order of a kilohertz. That's enough to contribute to the issue of whether you can copy it or not.

"Our frequency range is a compromise," Carl continues. "We could use 216 MHz, where antennas would be smaller, but increased multipath and foliage attenuation would make tracking more difficult. Frequency drift would be greater, too. My agency has a lot of equipment at 150 MHz for studying other endangered animals. We track anything big enough to carry a transmitter, but we haven't figured out how to tag butterflies yet."

Carl's crew glued the tiny transmitters with 6-inch thin-wire antennas directly to the fur of the captured bats. With luck, all of them would stay on through the study period and then fall off after the batteries were exhausted to minimize adverse effects of their weight. All bats were released at dusk. AB2SI did initial tracking from the air as they took off at 15 to 20 mph. The majority went south and the rest went north.

NYSDEC does aerial RDF with small fixed-wing aircraft. A Yagi antenna is mounted on each wing, aimed to the side. A switch inside the cabin chooses each antenna separately or both combined. When flying a grid search, Carl alternates



Carl Herzog, AB2SI, checks programming on a receiver. The bat transmitters are attached to cardboard.

between antennas to determine incoming direction of any bat signal he hears. "The airborne Yagis are usually 2-element," he explains. "We tried some 4-element models this year, but there wasn't any performance improvement and the pilots hated it because extra wind resistance slowed down the plane."

AB2SI says that on release night, a special search pattern is used: "We fly in circles around the site about three miles away and we listen only to the outside ring. When the bats fly under the plane and continue in the direction they're going, we pick them up. We plot our position on a laptop running mapping software with GPS, giving us the bearing of the animals' departure from site. As it turns out, they fly pretty much in a straight line to wherever they're going to go.

"On the following days, in daylight, we fly a grid search pattern to find them. It's fairly easy if we know the direction they took and they don't fly too far. We fly parallel lines spaced as far apart as we feel we dare, which in this case is about two or three miles. Under good conditions, our RDF range is three to four miles. These bats usually roost in trees during the day, so at 10 to 30 feet up they put out a good signal.

"Once we pick up a tag, we switch between left and right antennas. When it's stronger on one side, we tell the pilot to fly in that direction until the signal is equal strength on each side. Then we follow it along as far as we can until there is a sudden drop in signal strength. That usually means we are right over the top.

"For each fix from the air, we send the ground crew in because we want to locate and mark the exact tree. We are studying the characteristics of individual trees and their surroundings. Indiana Bats tend to pick large ones that are dead or dying and where the bark is peeling off. They like to crawl up underneath the bark. A substantial tree might have 50 bats in it, all arriving from the same winter site."

Plans were to have the plane up as much as possible for several days to help the ground trackers. Unfortunately, the weather did not cooperate. Rain severely limited the flying time. After a few days, Carl left the Watertown project in the hands of the ground crew as he and the other professionals headed 225 miles away to Kingston to tag 18 Indiana Bats for the second study.

Pat, The Bat Man

WN8Z says that his Geo Tracker almost looks like one of the bats. Three-element horizontally-polarized beams emerge from both the left and right front windows, held by homebrew brackets to aim them broadside to the vehicle. A ComSpec R-1000 connects to the left beam, his Yaesu FT-817 to the right beam, and an ATS wildlife receiver to a vertical antenna on the roof. All three receivers scan the six frequencies, pausing four seconds on each to make sure no pulses are missed.

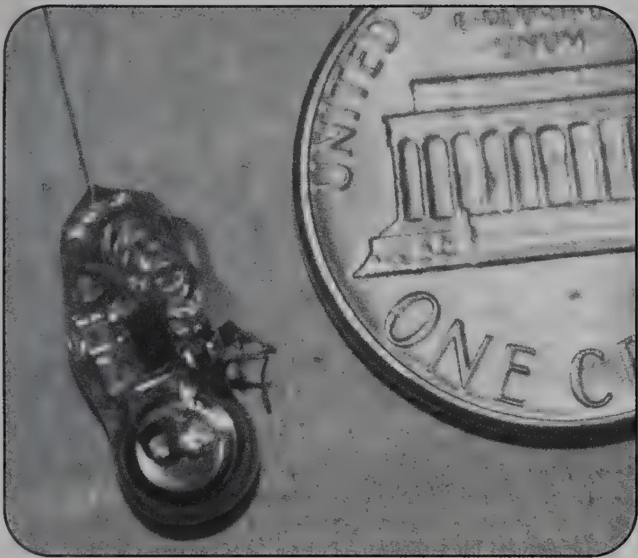
According to WN8Z, "It was a bit hectic at first juggling three receivers, but it's proven extremely effective. In one pass down a road, I cover the left and right sides with the horizontal beams. The $^5/_8$-wavelength omni hopefully catches the signals that tend to vertical. On the passenger seat I have my laptop fired up with Delorme Topo 5 and GPS, tracking my position. If I get a hit on a tag, I stop, park, and use the R-1000 and beam to shoot a bearing.

"I plot the beam heading on the laptop and move on to another spot to shoot a beam heading, then again draw the line on the laptop display. I do this from several locations if I have to. It's worked well. One bat was three miles away when I picked it up. The intersecting lines on the laptop brought me straight to the correct corner of the wooded area that I found it snoozing in."

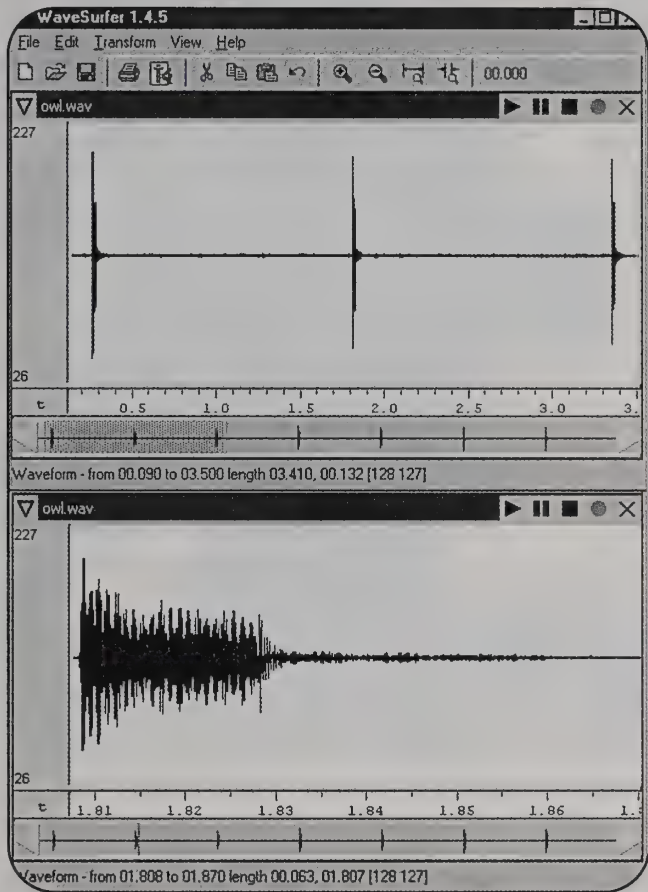
AB2SI agrees that as much RDF as possible should be done from the vehicle: "The first rule I tell people is not to walk anywhere that you can drive. A neophyte tendency is to get out upon first picking up a signal and keep running down the beam heading until they're standing in front of the tree. That's usually a mistake. Generally you should drive as much as possible to triangu-

The Watertown area bats spent the winter in this cave on the bank of the Black River.

Dit ... Dit ... Dit



A radio tag for a bat next to a U.S. penny for size reference. (Photo courtesy of Carl, AB2SI)



Audio waveforms of a wildlife radio tag as detected by a narrowband receiver with BFO. (By Joe Moell, KØOV)

Researchers have it relatively easy when studying large mammals and even some large birds such as the Sandhill Crane. They can place Argos satellite transmitters on them and see their positions on the Internet from their offices (for more on Argos satellite tracking, go to: <http://www.argosinc.com/system_overview.htm>). However, it takes at least a half watt to get the signal to a satellite. At 20 to 30 grams, Argos transmitters are too big and too heavy to place on sparrow-size birds and bats.

Government guidelines tell researchers to use radio tags that are only 3 to 5 percent of an animal's weight. AB2SI explains that his are as minimal as you might imagine, with a one-stage unshielded crystal oscillator powered by a hearing-aid-size cell. To maximize battery life, output is a 20-millisecond pulse about once every second or two. The pulse envelope is not rectangular, but quite ragged. There is a distinctive "chirp."

Weak short-pulsed signals are not well suited to spread-spectrum or Doppler RDF technology, so AB2SI's team has to track bat transmitters the old-fashioned way, using gain antennas and sensitive narrowband receivers with product detectors, just like amateur radio VHF weak-signal operations.

Do the tags harm the bats? "We do our best to take really good care," Carl says. "We have a vet on site when we're handling them. We feed them and give fluid injections to help them get over the trauma. With that, they seem to act in a totally normal way. They successfully integrate into the colonies and fly at normal speeds without any trouble."

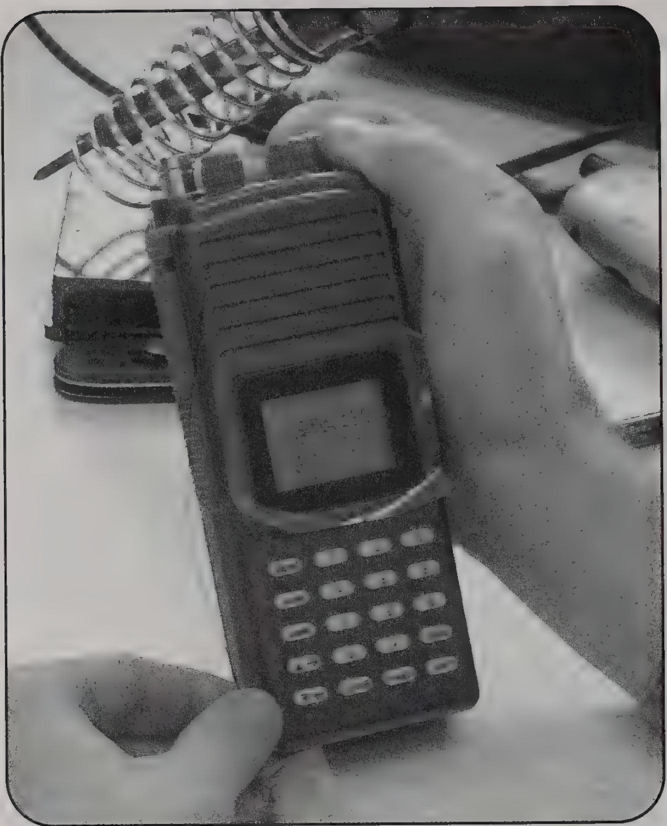
late and get a good idea where the bat is, circling all around it if necessary. Many an hour has been wasted walking, only to find the transmitter 100 yards from the road."

This was particularly good advice in some of the Watertown area terrain. "Those little girl bats really like the swamps," says Pat. "Multipath there is unlike anything I have ever experienced. The signal reflections can and will fool you. Slogging through muck and water thigh deep was a daily task, as we had to pinpoint these bats right to the trees they were napping in. This was the ultimate in low-power foxhunting; I don't think the USA Championships could be more difficult."

The territory was divided up among the team members. Pat sometimes worked all by himself. At other times he teamed with WA2ISC, whose primary mobile receiver was a Yaesu FT-100. "Kevin and I are both familiar with weak-signal VHF and have worked well together in our strategy of snagging signals," WN8Z says. "He is a long-time ham who retired from a career in telecommunications.

"We found that many of the bats were following Interstate 81 south of Watertown. There's not a lot of population in that area but it's a well-traveled corridor, so the cell-phone providers have towers on both sides every couple of miles. They are at the high spots, so Kevin and I started hopping them. We would go to each tower and beam down the corridor to see if any of the bats were in the area. In the first couple of days when the tag batteries were fresh, we were picking them up three to four miles away from those sites. When I found the actual tree, I checked the distance and it averaged 2500 to 3000 feet from the highway through swamps and woods.

"In the morning we would start tracking bats into the trees, record the exact coordinates, get in the car and find another signal to track. At night we did exit surveys. Each tracker would pick a marked tree towards dusk, get under that tree, and start watching to see if any bats exited to feed. If only one or two came out, they were probably still looking for a home and not going to stick around. On the other



The Communication Specialists R1000 wildlife tracking receiver. AB2SI is holding a transmitter in his left hand.

hand, if many came out, it indicated that a maternity colony was forming and they were going to stay in that area.

"When I am out of the car I always carry GPS. I set a 'car' waypoint when I leave my vehicle before heading into the unknown, and I wear it on a lanyard around my neck so that it tracks as I go. I also make sure to have a backup compass for the times when dense overhead cover blocks the GPS signals or when the batteries go dead. GPS is not an option for bio-tracking; it's an absolutely necessary tool."

It sounds like an old joke, but people actually do own swampland. According to AB2SI, "Almost all the time in this part of the country, the target ends up falling on private property. We don't have any authority to just traipse in there and find the bats, so we don't trespass unless we first make a lot of effort to find the owner. For the most part, we haven't run into much trouble locating them, but there are some absentee landowners in this part of the country, people living downstate in Long Island or New York City. Fortunately, our hams were locals and one of them seemed to know almost everybody in the county! He turned out to be quite an asset."

Another problem was false-alarm signals from local oscillators of scanners, not just those of the researchers but in homes and vehicles of nearby residents. AB2SI states that most false pulses were on 150.725 MHz, perhaps related to a local public-service agency being widely monitored.[4]

This year's study results were very pleasing to NYSDEC. Trackers located 26 of the 32 bats from Watertown and 16 of the 18 at Kingston. All were within 40 miles of the release site. None of the bats appeared to have ventured into adjacent states or Canada, but of course the team can't be sure about the few that it didn't find.

"The research is going to prove extremely valuable in our efforts to ensure the continued existence of this endangered species," Carl announced proudly afterwards. "Amateurs contributed significantly to this project. Frankly, we couldn't have done it without you. You can expect that others in the wildlife biology community will be looking to draw on your collective knowledge and experience in the future."

Great PR Opportunity

The sudden appearance of antenna-equipped vehicles and people running through backyards and wading through swamps waving aluminum raised a lot of curiosity, especially in tiny Adams Center, where many of the bats ended up. "This is an area where people still pull over to make sure everything is okay when they see cars parked alongside the road," says Pat. "This presented many chances to explain the basics with just the right emphasis on the 'why' of ham radio involvement.

"About a week into it I had a sign made up to cover my spare tire. You wouldn't believe how many people came up and talked to us to us after that. I think I had the youngest bio-tracker. A mother sought me out and told me her 11-year-old son wants to be a biologist. Could she bring him down to meet me and ask questions? Sure!

"I gave him an R-1000 and a 3-element handheld and showed him how to use it. Before we even moved he was saying, 'Are we going that way?' I said, 'You're the tracker, let's go.' Through the muck we went, four tenths of a mile in. I had no idea where we were going, but that little guy actually did a track and took us down to the tree.

"There was another group of kids that couldn't wait to get out of class every day to see if my car was parked down at the restaurant that we used as an office. They wanted to tell me what they had learned about bats since I last saw them. I'm planning a slide presentation to go into the schools and explain why we were there and what we do in amateur radio and biology."

I admit that I'm a bit envious of the experiences that these folks had in the swamps of New York State. Their experience

WN8Z's Geo outfitted for bat tracking. When cruising for signals, Pat has Yagis aimed left and right with a scanning receiver on each one, plus a third receiver on a vertical whip.

This Indiana Bat has just been fitted with a VHF transmitter and given a fluid injection.

was challenging, educational, rewarding, and fun. According to AB2SI, "They thought they should be paying us to do it!"

WN8Z agrees: "It was the ultimate in transmitter hunting. When Carl posted and I responded, I had no idea what to expect, nor any knowledge of bats. I had never owned a pair of hip waders in my life, but sure was glad I took Carl at his word when he told me to bring them. I am honored and proud to have been a part of this critical research team. We've all got our hands up for next year's study."

Pat also had high praise for New York area hams and scanner fans who monitored the six frequencies from their homes. "Your time and efforts were not in vain," he says. "Every day I talked with hams who devoted time listening from as far as 70 miles away and to others who were right in the Watertown vicinity. Every minute that each of you contributed to this project was worth 60 or more to us in the field. Negative data is valid data. By letting us know where you heard no signals, we could concentrate our time in other areas. Thanks to each and every one of you!"

Next year NYSDEC plans to tag and track Indiana Bats in the Syracuse area. Researchers studying other flying and crawling animals, including Burrowing Owls in southwestern states, are considering using ham help in the coming months. If this appeals to you, visit <www.homingin.com> for the latest news and information.

Please keep sending those stories and photos of RDF activities in your area to me for use in future "Homing In" columns.

73, Joe, KØOV

Notes

1. <http://www.fws.gov/endangered/i/a/saa08.html>
2. Biotrackers is an Internet mail reflector for persons interested in volunteer wildlife monitoring and tracking. To join, send an e-mail to <biotrackers-subscribe@yahoogroups.com> with no subject or text. To prevent spam, only list members may post and all new subscriptions must be approved by the moderator.
3. <http://www.com-spec.com/r1000/r1000.htm>
4. For details of the unique characteristics of these tags and how to distinguish false alarms, read the article "Was That Really a Wildlife Tag?" at <www.homingin.com>.

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

VHF+ on a Shoestring

Welcome back to the new "Beginner's Guide" column for the second installment! During the intervening months I hope you have taken a serious look at your plans for VHF+, have assembled a list of realistic goals for your proposed station (or possibly a station upgrade), and have at least done some research on the type of gear, accessories, and antennas you need to obtain to make it all happen. Should you be really industrious, quite possibly you've already procured some or all of the gear and are in the midst of making things come to pass. If so, good for you!

VHF+ Weak-Signal Station on a Budget

This column's subject matter resulted from my musings over "the goode olde days" during my tour of duty in England as G5CSU. I arrived in the UK in early 1979 and left in mid 1984. Undoubtedly, this was the best, most productive time of my Air Force career and equally productive in my pursuits in the amateur radio hobby.

The "blokes" have an entirely different way of doing things than we "Colonials." They design and build; we buy. The average British radio amateur has a very small station that features a mixture of homebrew and commercial gear. Due to the outrageous Value Added Tax (VAT), which tacks an extra 15% (at least that is what it was when I was there over 25 years ago) on top of each purchase, British hams tend to be frugal and build a lot more than their stateside counterparts. This is not a bad thing.

My family and I lived off base during my entire tour of duty in the UK. We were intertwined in the local culture, and that included all aspects of ham radio. I soon became a member of the G-QRP-Club and started building many small accessory projects from the pages of the club's quarterly newsletter, "SPRAT" (Small Powered Radio Amateur Transmissions). This led me to try more ambitious homebrew projects, resulting in my becoming a well-rounded radio amateur and dedicated homebrewer.

When we stateside hams think of 2 meters, we immediately think in terms of 2-meter FM and repeaters. Using the 2-meter FM repeaters in the UK was "different," to say the least. With only a handful of repeater pairs, the Brits had managed to make good use of their repeaters. However, the majority of 2-meter FM operation took place on simplex frequencies. Since the antennas were relatively small in comparison to HF antennas, and the British license structure was such that there were many more VHF license holders than HF license holders, it seemed only natural that there was a lot of VHF+ experimentation, in addition to FM activity, going on in the UK.

Early on in my tour I procured an ICOM 2-meter IC-202 (later I obtained an IC-202S, the last model of this line that featured both USB and LSB) along with an IC-402 for 70 cm. These little "Bookcase Radios" were produced from about 1979 to 1985. They featured SSB and CW operation and 3 watts PEP RF output—admittedly not a lot of RF, but when coupled to a good antenna system, more than enough to work all sorts of DX throughout Europe when conditions were favorable.

The Icom IC-202 is probably the cutest VHF rig ever built, and even by today's standards, still a capable exciter for use with a "brick" amp or, used barefoot for some QRP hill-topping outings. With 3W PEP output on 144 MHz, and a reasonable receiver (made better by some mods available on the Internet) the IC-202 is an inexpensive way for a neophyte VHF+ operator to break into the high bands.

My first station was just off base at RAF Lakenheath (Suffolk, East Anglia) and consisted of the IC-202 and IC-402 exciters feeding an 11-element Cushcraft 2-meter Yagi and a "no-name" brand 19-element Yagi for 70 cm. These two Yagis were stacked about 5 feet apart on a 30+ foot mast attached to the side of our house. Turning this affair was an old CDE 44 rotor that I bought from another ham who was leaving the UK shortly after I arrived. Both antennas were fed with RG-8U foam dielectric coaxial cable. The feedlines were each less than 25 feet in length, so even though RG-8 is not the preferred cable for UHF, coaxial cable losses were minimized due to their short runs.

At a "radio rally" (hamfest to you "Colonials") I obtained a Maidenhead grid map of the UK and Europe. One day the 2-meter FM simplex frequency came alive with chatter about a "lift" that was "on" (whatever *that* meant). I was soon to learn that a "lift condition" was what we in the states called a tropo-ducting event or possibly a sporadic-*E* propagation enhance-

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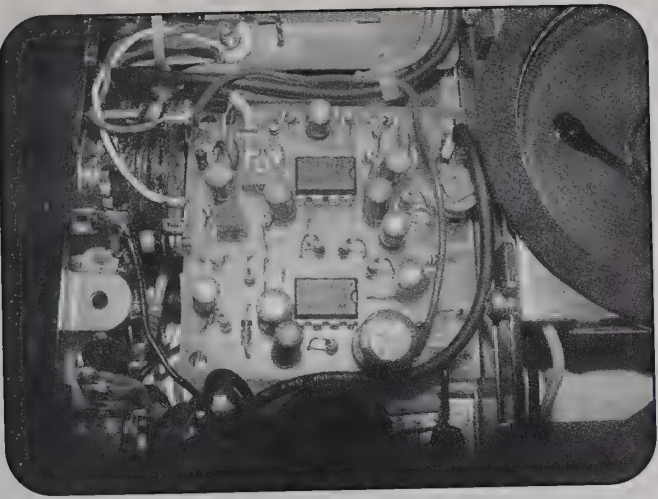


This photo shows a close up of the Ten-Tec speech processor that is wired into the audio chain right at the back of the mic plug. The speech proc, when properly adjusted, is a great way to maximize the miniscule 3W PEP output and make this rig sound a lot bigger than it really is. The speech processor mod should be considered if this radio is to be used barefoot or as a portable station for roving or hill-topping.

ment. At any rate, as I turned my small array east toward Europe, signals on 2 meters began to rise, followed by an increase in signals on 70 cm. Both bands were hopping, and I was soon engrossed in swapping signal reports and collecting grid squares from all over Europe, as my minuscule 3 watts of RF seemed to work miracles for over an hour.

In all my 17 years as a ham radio operator (at that time) I had never experienced anything remotely as hectic, frantic, and utterly fascinating as that first lift condition I experienced at my RAF Lakenheath QTH. Wow! When the bands opened up I quickly found that 3 watts (PEP) RF output was definitely up to the task of bagging some seriously rare grid squares. My QRP instincts were whetted, but most of all the lure of VHF+ had taken hold . . . and I was never the same again.

Back to VHF+ on a Shoestring . . .

Reminiscing about these days of yore in jolly olde England got me to thinking about how easy it would be to assemble a VHF+ weak-signal station that performed admirably under favorable propagation conditions with a paltry cash outlay. If then, why not now? That was the seed that started to germinate and resulted in my pitching this idea to Joe Lynch, N6CL, editor of *CQ VHF*.

Initially I had a Yaesu FT-857 on hand that I had intended to use as the prime mover for the frugal VHF+ station. Through a series of seemingly unrelated events, I ended up selling that radio and had nothing to use for my prime mover except my little Yaesu FT-817 QRP rig. That got me thinking about how difficult it would be to acquire the IC-X02 rigs again and assemble the same basic VHF+ weak-signal station I had originally used in England over 25 years ago.

Yea, Though I Walk Thru the Valley of e-Bay

Let me just say that e-Bay is a very evil place! It causes normal people, normally sane people, to do weird things such as spend lots and lots of money in pursuit of "stuff" that they *really* don't need. Having said all that, let me state categorically that without e-Bay I doubt that I would have assembled the entire range of IC-X02 rigs in such short time.

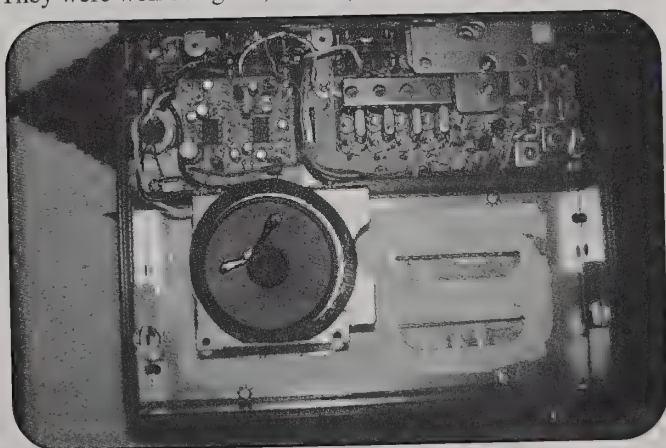
Starting with a plea on the QRP-L reflector, I soon had the IC-202 of Dave Benson, K1SWL, for a grand total of $75. Not bad! This was followed by an IC-215 for 2 meters FM from Keith Hibbert, WB2VUO, from the depths of the Great Bergen Swamp in upstate New York. Cost: trade for an old MFJ antenna tuner. Not bad! Another e-Bay deal netted the IC-502 for 6 meters direct from Japan. Cost: $130 sans s/h. Not great, but not all that bad either. The IC-402 came from a ham in Washington State for $125 less s/h. Again, not a stellar deal, but not a bad one either. So for a total cash outlay of $330, I assembled an entire trio of exciters for my VHF+ station within six weeks! In addition, I came up with a 15-channel, crystal-controlled 2-meter FM rig that matched the rest of the station. Who says you can't get good deals in this day and age?

With the exception of the IC-202, all of these rigs were in great physical and electrical shape. The IC-202 took some work to bring the case around and get rid of some grit and grime, but in the end the entire quartet of Bookcase Radios look brand new, and they are quite impressive all lined up on my operating bench! Now if I could just find all the matching 10-watt linear amplifiers and power supplies.

Why the IC-X02 Rigs?

With all the current crop of solid-state, microprocessor-driven DDS rigs on the market, why did I decide to use these 25-year-old ICOM rigs? Several reasons, actually. First, the availability and price of these rigs would allow a VHF+ neophyte the option of purchasing *just one* of the rigs (I'd start with 6 meters, personally) and give VHF+ operation a try without spending gobs of money and investing hours of time on assembling a state-of-the-art multi-band station. After all, if you spend a bundle just to find out that you really don't like listening to all that static for hours on end waiting for a band opening, then a small expenditure of funds is certainly more easily assimilated than one totaling many hundreds or thousands of dollars.

Second, the IC-X02 rigs were good performers, in their day. They were well designed, stable (thanks to their VXO design),



This is a wide shot of the battery box (note the flattened partitions) and the placement of the speech processor where the speaker used to live, and the subsequent repositioned speaker. The only major drawback to this method of mounting the processor is that the speaker no longer sits directly below the holes in the side panel, which tends to mute the receiver audio a bit. Headphones or an external speaker solves this problem. There is plenty of room for added mods in the modified battery box.

and could be powered from an internal battery pack made up of nine alkaline "C" cells. By today's standards, of course, they leave a lot to be desired, especially in the dial-readout accuracy area. However, a cheap counter will easily spot your rig's frequency within a couple of hundred Hertz, so that really is a non-issue.

Third, these rigs beg to be modified, upgraded, and enhanced by swapping out the older MOSFET active devices (3SK40s) in the receiver with GASFET devices (BF-981s) and adding things such as preamps, speech processors, "brick" RF linear amplifiers, etc. By being willing to undertake some basic mods, and with a little homebrew effort, we are going to learn some things about VHF+ operation. After all, if it were ultra-simple to assemble a good weak-signal station for the VHF/UHF bands, then it wouldn't be any fun, now would it? By modifying and upgrading these simple little rigs, it is possible to not only learn something new regarding this aspect of our hobby, but have some fun, improve our ham radio skills, and acquire some pride in accomplishment all at the same time.

My Goals

In keeping with the previous column's emphasis, here are the goals for my personal VHF+ weak-signal station:

1. Assemble a triband VHF+ station using IC-X02 radios as exciters.
   (a) Timeframe: on/before mid-February 2005.
2. Research the Internet and locate mods/upgrades for IC-X02 radios and perform mods as needed.
   (a) Timeframe: on/before mid-March 2005.
3. Construct two 2-meter Yagis using a July 1999 *QST* article, "A Five-Element, 2 Meter Yagi for $20" by Ron Hege, K3PF.
   (a) Timeframe: on/before April 2005.
4. Erect "V/UHF Short Stack" for 2 meters and 70 cm.
   (a) Timeframe: third week in April 2005.

These four short term goals, if accomplished on schedule, will allow me to have an operational triband (6 meter, 2 meter, and 70 cm) weak-signal station operational before my foot surgery. This operation will keep me away from work for about six to eight weeks. Having the station operational prior to the surgery will allow me to participate in one or more contests during my recuperation period, all with minimal cost outlay.

Okay, so how have I done so far? Well, the IC-202 receiver has been upgraded with the replacement of the 3SK40 device in the first mixer with a GASFET BF-981 which, according to the published modification, will decrease the overall noise figure (NF) of the radio by at least 2 or more dB. In order to get the "new" Q2 to function properly, you must mount it on the underside of the main PC board (remove the battery tray and access is easy!) and then short out R6 (check your schematic diagram) to properly rebias the BF981 device. In addition to the BF-981 mod, I also added a Ten-Tec T-Kit model 1551 speech processor (at a whopping $14.00 + s/h) to the transmit audio chain, and I have also bypassed the LC tuned filter in the receiver front end of the IC-202 for an additional NF decrease of about 2 dB. This LC filter is shared by the transmitter (it is the PI output filter that keeps the transmitter output clean) with the receiver input signal. While the filter is definitely needed on transmit, it is not necessarily required for receiving, and bypassing this filter definitely makes an improvement in the overall receiver NF.

Thus, for a minimal amount of work and a relatively small cash outlay, I have made approximately a 4-dB or better improvement in receiver noise figure (no small task), while substantially increasing the average DC output power of the QRP transmitter using the T-T speech processor. Coupling this modified exciter to a 35- to 70-watt 2-meter "brick" amplifier will yield a nice little 2-meter weak-signal station that can hold its own when coupled to a good set of antennas. Life is good!

The mods on the IC-202 are at <http:// www.qsl.net/pe1hwo/icom/ic202/mods/>, <http://www.hamdirectory. info/ICOM_VHF.html>, <http://users3. ev1.net/~g4fre/Ic202rx.htm>. The Ten-Tec website (www.tentec.com) will provide access to its secure site to purchase one of the T-Kit model 1551 speech processors. Once built, the processor is placed inside the IC-202 where the internal speaker normally sits, and is wired directly between the mic input and the main PC board where the mic plugs into the board using subminiature coaxial cable.

Take a close look at the photographs showing the placement of the speech processor and the repositioning of the internal speaker. Since this particular radio will not be used with internal batteries, the battery compartment of the IC-202 radio makes a great place to put mods such as preamps, speech processors, etc. With a little ingenuity, there is no doubt that someone could come up with a small 10–15 watt linear RF amp that could be added to the internal battery box of one of these little ICOM rigs, boosting the power output while maintaining everything internal to the radio!

Additional info on the BF981 device used in the mods on the IC-202 (replacement of Q2) can be found at: <http:// www.geocities.com/toddemslie/bf981_preamp.html>.

Notice that on my particular IC-202 I have flattened the internal baffles that separated the battery stacks inside the battery box to form a solid metal platform on which to affix some more modifications and circuit boards. One particular mod I am going to perform is to solid-state the T-R switching for CW. These rigs (all of them) have a front-panel switch that selects the CW mode, and that switch *must* be thrown *before* you can key the transmitter. Full break-in (QSK) it's not! My goal is to homebrew a solid-state switch that will work on key closure. Along this same line of thinking, I will be adding a Pic keyer chip from K1EL that has my callsign along with several embedded messages burned into the chip's memory. All I have to do is plug in the paddle set or a straight key and start sending CW. No switch throwing needed!

A final thought for this installment—frequency accuracy. Unfortunately, these cute little VHF+ rigs were manufactured just before digital readout became a standard feature on most radios. There are several modifications on the Internet that detail how to add a digital readout (more appropriately called a "digital dial") to these rigs (check <http://www.vhfman.freeuk.com/radio/ic202.html>). Due to the fact that these radios and their associated mods (many of them originating in Europe; I guess the IC-X02 series never became all that popular in the U.S.) are 15 to 20 years old, I am sure that there are much more refined methods of adding digital readout to these rigs. I will be researching this aspect and will report on what I find at a later date. Realistically, there should be a one or two chip circuits circulating out there on the web that when coupled to the IC-X02 local oscillator could easily be programmed to read the exact operating frequency to within several Hertz.

That's all for this installment. Please feel free to e-mail me (k7sz@arrl.net) with your questions and comments and any ideas you might have regarding this column. If you have done your homework, don't hesitate to send me pictures (with captions) of your station and I will do my best to get them into this column.

73, Rich, K7SZ

QUARTERLY CALENDAR OF EVENTS

Current Contests

August: The **ARRL UHF and Above Contest** is August 6–7. The first weekend of the **ARRL 10 GHz and Above Cumulative Contest** is August 20–21.

September: The **ARRL September VHF QSO Party** is September 10–12. The second weekend of the **ARRL 10 GHz and Above Cumulative Contest** is September 17–18. The **144 MHz Fall Sprint** is September 19, 7 PM to 11 PM local time. The **ARRL 2304 MHz and Above EME Contest** is September 24–25. The **222 MHz Fall Sprint** is September 27, 7 PM to 11 PM local time.

October: The **432 MHz Fall Sprint** is October 5, 7 PM to 11 PM local time. The **Microwave (902 MHz and above) Fall Sprint** is October 15, 6 AM to 1 PM local time. Note, you are to operate no more than five hours, in one-hour blocks during this contest time slot. The **50 MHz Fall Sprint** is 2300 UTC October 22 to 0300 UTC October 23. The **ARRL 50 MHz to 1296 MHz EME Contest** is October 22–23.

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 13–13.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or go to: <http://www.arrl.org>. For Fall Sprint contest rules, see the Southeast VHF Society URL: <http://www.svhfs.org>.

Current Conventions and Conferences

September: The 2004 **TAPR/ARRL Digital Communications Conference** will be held September 23–25, 2005, in Santa Ana, California, at the Embassy Suites Hotel, Orange County Airport North. For more information, see: <http://www.tapr.org/dcc/>.

The **Mid-Atlantic States VHF Conference** is to be held Saturday, September 24, at the Courtyard Marriott, 3327 Street Rd., Bensalem, PA 19020; phone: 215- 639-9100. For further information, contact the conference chairperson: Jim Antonacci, WA3EHD, 215-659-4359; e-mail: <jantonacci@worldnet.att.net>, or Rick Rosen, K1DS, 610-270-8884; e-mail: <rick1ds@hotmail.com>. The web site for further info and maps is: <http://members.ij.net/packrats/latest.htm>.

The **Pacific Northwest VHF+ Conference** will be held September 30-October 1, at the Shilo Inn and Oceanfront Resort in Seaside, Oregon. For more information, see their URL: http://www.pnwvhfs.org.

October: The 2004 **AMSAT-NA Space Symposium and Annual Meeting** is to be held October 7–9, in Lafayette, Louisiana, at the Holiday Inn Central, located in downtown Lafayette, at the intersection of I-10 and I-49. For more information, please see the AMSAT URL pertaining to the symposium at: <http://www.amsat.org/amsat-new/symposium/>.

The annual **Microwave Update** conference dates are October 27–31, and it will be held at the Sheraton Cerritos Hotel, Towne Center, 12725 Center Court Drive, Cerritos, California 90703. For more information, please see the North Texas Microwave Society's URL: <http://www.ntms.org>.

Quarterly Calendar

Aug. 4	Moon Apogee
Aug. 5	New Moon
Aug. 12	*Perseids* Meteor Shower Peak
Aug. 13	First Quarter Moon
Aug. 19	Full Moon
Aug. 19	Moon Perigee
Aug. 26	Last Quarter Moon
Sept. 1	Moon Apogee
Sept. 3	New Moon
Sept. 11	First Quarter Moon
Sept. 16	Moon Perigee
Sept. 18	Full Moon
Sept. 22	Fall Equinox
Sept. 25	Last Quarter Moon
Sept. 28	Moon Apogee
Oct. 3	New Moon
Oct. 10	First Quarter Moon
Oct. 14	Moon Perigee
Oct. 17	Full Moon
Oct. 21	*Orionids* Meteor Shower Peak
Oct. 25	Last Quarter Moon
Oct. 26	Moon Apogee
Nov. 2	New Moon
Nov. 9	First Quarter Moon
Nov. 9	Moon Perigee
Nov. 16	Full Moon
Nov. 17	*Leonids* Meteor Shower Peak
Nov. 23	Last Quarter Moon
Nov. 23	Moon Apogee

—EME conditions courtesy W5LUU.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. To date this year the following organizations or conference organizers have announced calls for papers:

The **Mid-Atlantic States VHF Conference**: Please submit your paper as soon as possible to: Paul Drexler, W2PED, 28 West Squan Rd., Clarksburg, NJ 08510, or via e-mail to: <pdrexler@hotmail. com>. The listed deadline is July 31, but you may have a day or so after that date if you notify Paul of your forthcoming submission.

TAPR/ARRL Digital Communications Conference: Technical papers are solicited for presentation at the 24th Annual ARRL and TAPR Digital Communications Conference to be held September 23–25 in Santa Ana, California, and for publication in the conference *Proceedings.* Submission of papers is due by August 9 to: Maty Weinberg, ARRL, 225 Main St., Newington, CT 06111; or via the Internet to: <maty@ arrl.org>.

Microwave UpDate: The deadline for inclusion in the *Proceedings* is September 5. If you are interested in writing and/or presenting a paper for the 2005 Conference, contact: Chip Angle, N6CA, P.O. Box 35, Lomita, CA 90717-0035; or via e-mail: <n6ca@ham-radio.com>. For more information about Microwave UpDate 2005 go to: <http://www.microwaveupdate.org>.

Meteor Showers

August: The *Perseids* meteor shower is predicted to be August 12. For more information on this shower, please see the "VHF+ Propagation" column on page 60.

October: The *Draconids* is predicted to peak somewhere around 1600 UTC on October 8. The *Orionids* is predicted to peak on October 21.

November: The *Leonids* shower is predicted to peak around 1430 UTC on November 17.

For more information on the above meteor-shower predictions visit the International Meteor Organization's URL: <http://www.imo.net>.

By Bob Witte,* KØNR

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

A New Voice on FM

If you have been receiving *CQ VHF,* you will notice that there is a new author for the FM column in this issue. You may recall that in the Spring 2005 issue Gary Pearce, KN4AQ, announced that he was no longer going to write this column. I quickly volunteered to take over the responsibility. I want to thank Gary for writing a great column over the past three years. I've always found it interesting, and I will strive to maintain that quality and continue to improve upon it.

At first glance, writing the FM column might look easier than writing some of the deeper technical articles. This is true in terms of pure technical challenge. A challenge with this column, though, is dealing with the diversity of how hams use VHF FM. It really is the "utility mode," the band/mode that hams use on a regular basis to get things done. Some use it for chatting around town on simplex, while others make contacts on the local repeater system. Some radio amateurs are interested in building complex repeater systems; others just use them. VHF FM is also a very popular mode for working the OSCAR satellites. This can make writing about FM difficult, since the audience is somewhat fragmented. In many ways, VHF FM is taken for granted. too, since it is always there waiting to be used.

Frequency Modulation

FM is an interesting mode and VHF FM is arguably the most popular type of ham radio operation today. Let's take a look at some of the characteristics of FM.

Edwin H. Armstrong first described the practical use of *frequency modulation* in "A Method of Reducing Disturbances in Radio Signaling by a System of Frequency Modulation" published in May 1936 by the Institute of Radio Engineers (IRE). The article is located online at <http://michael.industrynumbers.com/fm.pdf>. The first practical two-way FM radio telephone mobile system in the world was designed by Daniel E. Noble and implemented in 1940 for the Connecticut State Police. Clearly, FM radio has been around for a while!

FM certainly has gained acceptance in a variety of radio applications, including FM broadcast, television audio, two-way mobile radio, and VHF/UHF amateur radio. Like most technologies, FM has its advantage and disadvantages (see Table I). Let's compare FM (5-kHz deviation, as employed on the VHF+ ham bands) to the other popular phone mode, single sideband (SSB).

FM receivers tend to ignore amplitude variations in the signal, so many sources of electrical noise largely are suppressed. I was reminded of this during the recent ARRL June VHF contest when a thunderstorm approached from a distance. Every time there was a lightning crash, my 2-meter SSB transceiver put out a burst of noise in response, while the 2-meter FM transceiver remained silent. Armstrong emphasized this characteristic of FM for broadcast use as a distinct advantage over AM radio technology. (For a brief history of the development of FM, read Armstrong's article "Evolution of Frequency Modulation" (go to <http: www. mcmlv.org/Archive/Radio/FM_Armstrong.pdf).

Photo A. The Motorola HT-220 VHF handheld transceiver was a breakthrough product that many hams adapted to the amateur bands. →

Armstrong also promoted the high-fidelity nature of FM audio, a clear advantage in the broadcast arena but less so for two-way radio. Still, it is nice to have good, clean audio that is easy to understand and sounds like the original speaker.

Modern applications of FM in two-way radios include a squelch circuit that mutes the receiver until a signal is received. This makes for easy monitoring without having to listen to background noise. While there are SSB radios with squelch, the squelch operation is not nearly as decisive and accurate in determining when a signal is present.

Another key advantage of FM is the tolerance of error in the carrier frequency. In normal VHF ham radio use there is often a mismatch of over 1 kHz between the transmit frequency and the receive frequency. This kind of frequency error usually goes unnoticed on FM. Try this on SSB and you'll find that the received signal sounds like a very annoying Donald Duck. This

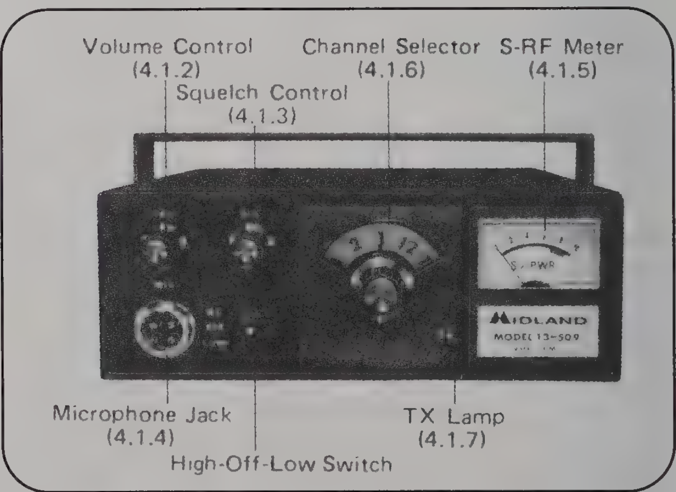


Photo B. The Midland 13-509 VHF radio is the 220-MHz version of the 2-meter transceiver mentioned in the article. The radios are the same except for frequency band. (From the original Midland manual)

*e-mail: <bob@k0nr.com>

About The Author

Since the beginning of my amateur radio activity I've been interested in the VHF and higher bands. I think it started when I discovered that the 2-meter band had such a variety of operating modes (FM simplex, repeaters, SSB, CW, satellite, etc.). Later on I learned to appreciate 6 meters, appropriately known as The Magic Band, due to the frequent sporadic-*E* openings that really spice up things.

I enjoy building and using FM repeater systems, mostly on 2 meters and 70 cm. Over the years I've served on a number of technical crews for various repeater groups. Currently I operate the KØNR/R repeater in Monument, Colorado on 447.725 MHz with a frequency-agile 2-meter remote base and autopatch. The repeater has a weather radio connected to it that automatically activates a warning message on the repeater output when the National Weather Service broadcasts a warning. Although the repeater gets used every day, its real role in this world is to provide a place to experiment with repeater ideas.

While most of my operating is above 50 MHz, I have spent plenty of time on the HF bands. I've made enough contacts to qualify for WAS, WAC, and DXCC. At times I have done quite a bit of CW operating, and I passed the 20-wpm code test to get my Extra Class license many years ago.

CQ VHF *FM columnist Bob Witte, KØNR.*

Still, home base for me is always VHF and higher. My present passion is operating QRP on VHF and I write a column for *QRP Quarterly* on that topic. I usually am active during the major VHF contests, often operating from some mountaintop or other high-altitude location. If you want to know more about ham radio interests, please visit my website: <http://www.rwitte.com>.

Photo C. The Yaesu FT-208R was an early synthesized 2-meter handheld transceiver. (Photo courtesy of the <www.rigpix.com> website)

advantage of FM comes into play when any kind of tone signaling is used, such as DTMF, paging tones, and CTCSS. Try using tone signaling on SSB and you'll find precise tuning of the carrier frequency is required.

If FM is so great, then why isn't it used everywhere? For starters, FM has very poor weak-signal performance. That is, when the signal level starts to decrease with FM, it hits a point where the received signal rapidly becomes very noisy and difficult to copy. This is called the *threshold effect,* since the received signal hits a threshold below which the signal is difficult to recover. On the other hand, SSB signals gradually get noisier as the signal level decreases and can be copied at much lower levels than FM.

The other big disadvantage of FM is that it uses a wider bandwidth than the equivalent SSB signal to transmit the same basic voice information. On the VHF ham bands, FM is about 16 kHz wide compared with SSB which is roughly 3 kHz wide. Thus, FM takes up about five times the frequency space as SSB.

FM also has the characteristic of being "full on" any time the transmitter is keyed. When you press the Push-to-Talk button, the transmitter puts out full RF power regardless of whether or not you are speaking into the microphone. This is referred to as having a duty cycle of 100%. Compare this with SSB, where the RF output power tends to follow your voice modulation as you speak. This means that for the same voice signal being transmitted, an SSB transceiver will tend to use less power. This is another way FM is less efficient than other modulation techniques.

My FM VHF Story

Let me tell you a little bit about my journey through the world of FM VHF. If you have had some of these experiences, perhaps it will jog your memory. If not, perhaps it will provide some insight on how FM VHF evolved.

I first became aware of the world of FM VHF when I was an electrical engineering student at Purdue University in 1976. I did not have my amateur radio license at the time, but I had just discovered that the radio club on campus was offering license classes. I quickly joined the class and was on my way to getting my Novice license, later to be followed by my Technician license. There was a ham in one of my EE classes who was carrying around the coolest radio of the day—the Motorola HT-220 (photo A). This thing was the size of a small brick (7.6 × 2.8 × 1.5 inches), so it was large by today's standards. Back then it was the most compact handheld transceiver that you were likely to find on the VHF bands. A search on the web revealed that there are still quite a few HT-220 enthusiasts out there. Check out the HT-220 home page (http://www.batnet.com/mfwright/mfwright/HT220.html), which is dedicated to information on that Motorola radio. Even though I lusted after such a compact and totally cool handheld, the going price for that radio was way out of my price range.

My first VHF transceiver (and my first ham transceiver) was a Midland 2M FM mobile rig, Model 13-500 (photo B). Of course it was crystal controlled, since almost all of the FM VHF gear was crystal controlled back then. Like most radios at the time, it required two crystals per channel, one for transmit and one for receive. It came standard with a pair of crystals for 146.52-MHz simplex. If I remember correctly, it also came with a

Photo D. An assortment of modern portable VHF/UHF amateur radio transceivers.

pair for 146.34-MHz TX/146.94-MHz RX, the so-called "three-four/nine-four" pair. This was the most popular repeater pair at the time. The rig also had a 146.94-MHz transmit crystal, so one of the channels was set up to run simplex on 146.94 MHz. To use the repeater at Purdue, the rig had a 146.16-MHz TX/146.76-MHz RX crystal pair. It was also set up for running simplex on 146.76 MHz. With crystals going for at least $5 each ($10 per pair), it was easy to add $100 or so to the cost of the 12-channel transceiver.

Of course, this was the problem with crystal-controlled radios. You spent a bunch of money filling out the channels and then you still might not have the right frequency pair. Imagine driving across country, hoping you had the right crystals for the available repeaters. The radio I should have purchased was the ICOM IC-22S, which was one of the first cost-effective synthesized 2-meter transceivers. It had a diode-matrix that did the programming of the synthesizer, so you could set up the 22 channels to your favorite frequency pairs (never having to buy a crystal). If you changed your mind or your home location, you could reprogram the channels by moving the position of the programming diodes.

Speaking of synthesizers, I remember one of my fellow college students had an HT-220 with an add-on synthesizer that could tune any frequency without the need for crystals. Unfortunately, the synthesizer made the transceiver about 50% bigger and reduced the battery life to about five minutes (okay, maybe it lasted longer than five minutes, but it really consumed the

Frequency Modulation

Advantages	Disadvantages
High noise immunity	Poor weak-signal performance
High-quality audio	Relatively wide bandwidth
Clean squelch operation	100% duty cycle, independent of modulation
Tolerance of errors in carrier frequency	

Table I. Advantages and disadvantages of FM versus SSB for amateur radio use.

batteries quickly). I remember that the talk around the radio club was that synthesizers were just no good for handheld radios. Of course, it wasn't but a few years later that the major ham equipment manufacturers proved that notion wrong by introducing synthesized handhelds (with reasonable battery life) such as the ICOM IC-2AT, the Kenwood TR-2400, and the Yaesu FT-208R (photo C).

All modern VHF/UHF ham transceivers are synthesized, covering their respective frequency bands right out of the box. What an improvement over the old crystal rigs in terms of frequency agility! Think about organizing a local ARES exercise with crystal-controlled rigs; you had better make sure everyone has the right crystals plugged into their radios. There will be no last-minute arbitrary frequency changes. It puts a special emphasis on the concept of having a standard calling frequency. Everyone had crystals for 146.52 MHz, as it was the least common denominator.

Modern VHF FM rigs continue to amaze me (photo D). I suppose I should be used to it by now, but being able to buy a fully-synthesized 50-watt 2-meter transceiver for under $200 still amazes me. These rigs come with all the bells and whistles . . . maybe *too many* bells and whistles.

The Column . . . Going Forward

I've always been a fan of *CQ VHF* magazine, so I jumped at the chance to do this column. My request to you is for you to send me your ideas on VHF FM and provide feedback on the column. I think it works best if the column is interactive. In fact, I'd be willing to hand the keyboard over to you for an issue if you have a particular topic worth writing about, so send me your ideas!

There are a number of things concerning VHF FM that I am likely to address in this column. For starters, it seems that while VHF FM is still a very popular mode, on-the-air activity is declining. I often scan every repeater frequency in my area and the frequencies are generally quiet. This is noticeably different from a decade ago. Hams in other parts of the country report a similar pattern. I've spent less time monitoring the simplex frequencies, but they also seem underutilized.

Another current topic is the use of digital technology on the VHF bands—or more correctly, the distinct *lack* of use of digital technology. Sure we have AX.25 packet radio, including APRS (Automatic Position Reporting System), but what about using the latest digital modulation techniques for our next generation "utility mode"? Mobile phones largely have switched to digital technology, and the remaining analog cell sites are being phased out. APCO (the Association of Public-Safety Communications Officials) has established a digital radio standard known as APCO 25, or Project 25, for use with public-safety mobile radios. For more information on APCO or Project 25, please see: <http://apcointl.org/frequency/project25>.

Is there something different about ham radio communications that drives us to stay with good old analog FM, or are we just a bunch of Luddites? ICOM recently introduced transceivers that are based on the D-STAR standard. For more information on D-STAR, go to ICOM's website: <http://www.icomamerica.com/amateur/dstar>. Is this the future of digital communications for VHF and up? I'd like to hear from anyone using D-STAR or APCO 25 on the ham bands.

In future columns I am sure I'll cover some technical topics such as repeater systems, FM modulation and deviation, mobile antennas, HT antennas, tone signaling, etc. Some operating-oriented topics also come to mind, such as using FM VHF during Field Day, using FM during VHF contests, and general mountaintop portable operating.

For the most part, FM VHF is a local phenomenon. Issues and activities occurring in New York City may not be the same as those in the middle of Nevada. This is a place where I need your help in rounding out the column with information on what is happening in your corner of the ether.

That's all for this issue. Please let me know what you are doing in the world of FM VHF/UHF. Be sure to let me know your thoughts on any of the topics mentioned above. Reader feedback is always encouraged!

73, Bob, KØNR

By Chuck Houghton,* WB6IGP

2-Meter Multimode Radios Used in Microwave IF Transverters

Microwave transverters and even the VHF transceivers that are used with them as low-frequency IF radios all have one thing in common that we take for granted—the exceptional frequency stability that we have come to enjoy in equipment available in today's electronic market.

It was not long ago when all VHF equipment was crystal controlled, be it military surplus or equipment such as the Gonset communications equipment, which was AM-only operation and had vacuum-tube construction. Today, crystal-controlled operation is still in use with some of the available radios, but most multimode radios now use some form of phase-locking oscillator in the microwave transverters to a synthesized IF radio that is frequency agile and supports multimode operation.

Adapting these radios for IF-frequency service to be used with converters from microwave frequencies can be trying in some cases and easy in others. I thought I would take the time to answer questions that have popped up concerning what IF radio system I would recommend for converter operation.

Well, for me that's easy, in that anything that is economical (a bargain) and functions is just great. Taking the other extreme, a system can be homebrewed using key component parts widely available today. This would allow the hearty to construct their own receiver or even a transceiver for use as an IF converter in our microwave systems. It is one way, hard as it may be. I would like to spend the time operating on a hilltop rather than designing an IF system. That leaves one choice available for me, and it's the used surplus market.

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Putting Together the System

In any case, constructing a microwave transceiver is based on the components and systems we can locate to bring the design to fruition with economy and functionality. All transverters consist of a local oscillator, RF preamp, and transmitter power amp, along with coaxial relay switching for conversion from a high microwave frequency to a low-frequency IF system. This design, at least for the transverters I have built, is based on the IF system I plan to use for the transverter. In almost all cases this is an all-mode transceiver for 2 meters. However, a 70-cm all-mode transceiver can be used just as well.

For most amateurs, the IF system is whatever can be found inexpensively in the used surplus market or at local swapmeets. Juggle what you have for an LO (local oscillator) and what is needed for an IF system to convert the high frequency to your IF system. Two meters allows for simple filters to get rid of the other mixer products in converting from a microwave frequency to your IF radio. For example, it gets harder to use a 28-MHz IF radio for conversion; it will work, but the filters required must be quite sharp in bandpass to eliminate 28-MHz harmonics. With a 2-meter IF, the products are now 144 MHz apart and easier to filter out.

For start-up 2-meter equipment, there are many transceivers that could be used. This includes the ICOM 820H, or other great rigs that cover both 2 meters and 70 cm. Although they can be used, it would be overkill in using such an expensive radio for IF use. I prefer to work out of the junk box and not push my credit-card limits.

These rigs will work well, but as it is with all things, there are other points to consider. One of the modifications required to an expensive, high-power output radio the consideration of how to reduce the output power (10 to 50 watts) to a level capable of driving a mixer in transmit, reduced in power to something less than +20 dBm (100 mw). In this case I prefer not to modify such a radio, but rather leave it in its original

One of the Kenwood TS-700A 2-meter transceivers that I use for 1296 MHz and 10368 MHz (10 GHz) operation in my home shack. It's an old, but good radio for shack use. It is easy to modify for low RF power output, has dial frequency control for totally manual operation, and is good in any lighting conditions. It also has an internal AC power supply for ease of operation in the shack. Cost is about $50 used and working.

condition so as not to cause it harm or ruin its value.

For the IF radios that I use I achieved this low-power level of operation through an easy modification to the IF radio. It is simply soldering the low-power switch to provide low-power output all the time, disallowing high-power operation. My ICOM IC260 is wired this way. This modification, used with a home-built switching circuit that incorporates a 5- to 10-dB attenuator constructed out of 1/4-watt resistors, brings the IF radio system down to a power output level of something in the 100-mw range. This power level will not destroy any microwave converter or mixer circuit should the relay switching fail and you transmit with this power level into the receive mixer preamp of the microwave converter. The modification using 1/4-watt resistors is economical compared to using a high-power attenuator of 30 to 40 dB for the 1- to 10-watt power output levels.

Power levels above +20 dBm can and will blow a microwave mixer. Sure you purchase a replacement mixer at a premium price, but why go to the trouble of working with 10 watts or more in some transceivers just to attenuate the high power that has to be reduced for converter use? Using a low-power, modified 2-meter transceiver for use with your microwave converters, especially a transceiver obtained from the used surplus market, can be a very good choice when compared to an expensive rig that would better serve as a liaison radio.

The Radios

Let's take a look at some of the radios I have used for converter use and the simple mods, liabilities, and attributes of each.

The following 2-meter multimode radios are not the only possible ones, but they happen to be the ones I have stumbled upon at swapmeets and such over the years. These are all radios that I have in my shack at present. I did not want to modify my ICOM 820H in any way, and thus preferred to obtain a transceiver from the used market and convert it for my carry-around, knock-about IF system for microwave converters. A benefit is lower cost for used older equipment.

Using an expensive radio such as the IC-820H can be justified for base station for transverter IF use, but I still prefer to use the radio for liaison operation from the home QTH. For 2-meter IF strips at my QTH I use the Kenwood TS-700A. I have three that I use as these strips—one for 1296 MHz, one for 10,368 MHz, and one as a backup spare. This is an old radio but a good one and is very inexpensive. The highest price I ever paid for one is $65, which is not a bad deal, as they are easy to modify. A problem with the TS-700A, though, is the dial VFO mechanism seems to use a roller coil that develops rough spots and thus poor connection of the roller inductor track operated by the main tuning dial. This is not a big problem, however, and can be fixed by rolling the dial over these spots with a back and forth motion to clean the track on the main tuning dial. One of these days I will tear apart the TS-700A to fix this problem once and for all.

There are a lot of options on the used surplus market. Older multimode 2-meter rigs that do not have CTCSS tones for modern repeater operation are available and can be a good to look for. Rigs I have found include the ICOM IC-245

The SANTEK LS-202 multimode 2-meter HT. This one still works well even after being dropped, which cracked the battery compartment. Repairs included a new external volume control, and a 5-pF cap to replace the unobtainable final RF transistor, providing low RF power output for converter use. The masking tape shown here is needed to hold the battery compartment on the HT body. The plastic clips to hold the radio together had broken off long ago. A common problem with this radio is the audio pot going open and it having to be replaced with an external pot.

The ICOM IC-260 multimode radio. This one still serves as my backup radio, it being the easiest radio with which to operate 2 meters SSB. Its only drawback is the red LED dial, which needs to be shaded from direct sunlight to be able to read the display. When contemplating outdoors operation, I usually tape cardboard over the top of the unit, shielding most of the sunlight from the dial.

with SSB adapter and the Kenwood TS-700A, as mentioned. As the ICOM rig is smaller, it is the better choice. The Kenwood rig is more of a base-station radio. However, the Kenwood can be converted to 100 mw output power with the addition of a pad made from three each 1/4-watt resistors with a 4-minute modification. This pad can be removed and installed easily such that the radio can be returned to its original condition.The pad is installed on the inside bottom cover on the drive coax to 10-watt module input in series with the coax to termination point on the 10-watt module. What is required is a 10- to 15-dB pad. With the pad, maximum power is just under 100 mw power out. It has worked well for years in my home shack.

Another 2-meter, all-mode transceiver is the Yaesu FT-480R. It has a high/low-power switch that can be locked on low power by soldering a jumper. Then all you need to get rid of is 1 watt of power or less to reach the mixer driving power of something less than 100 mw. A consideration here is that the Yaesu FT-480 has a dial that uses a green display which is good for sunlight, while the ICOM IC-245 used a red LED that is very difficult to see in sunlight. (Note that the FT-780R, which looks exactly like the FT-480, is for 450 MHz. Be careful when you look at these radios to be sure you get what you want—the 2-meter version or the 70-cm version.)

The Kenwood TS-700 has a mechanical dial that is easy to see in any lighting conditions, and conversion to low power is quite easy. Just insert a 10- to 15-dB 1/4 -watt resistor "T" pad in the drive cable to the final amp compartment in series with the drive coax cable and amp box feed-through with the shunt resistor tied to ground.

Another consideration in a 2-meter, all-mode radio, but one which is harder to locate, is the Santek LS-202 handheld. This is an SSB/FM handie-talkie. I use this radio for lots of things. While it uses a manual frequency control, backed up by a plus/minus frequency adjust knob that is helpful, frequency accuracy is not apparent on this HT. However, for test work and general operation it a great find. I found mine in a repair shop in Colorado, with parts hanging out of the unit (a basket case). I was told the receiver worked, but due to the unusual grounded case to collector configuration on the power output transistor, the shop owner could not find a replacement final transistor. I told him that it was great anyway, and I purchased it for a song. I then replaced the final transistor with a 5-pF capacitor and the HT now puts out 60 mw, if I talk really loud.

Another radio that should be considered is the ICOM IC-260. Again, it is available because there are no CTCSS tones for repeater operation. It has a red LED for dial calibration, which is a negative point, but that is not insurmountable. It is easy to convert to low power, 100 mw or less, and is just as easy to return to its original condition. The best thing is that it is not very expensive on the surplus market—possibly $100 fully working. Low-power conversion consists of setting the switch to low power by removing the bottom cover plate and soldering the jumper on the switch, making it permanently on low power even if the switch is set to high power. The drive filter circuit can easily be tweaked to obtain 60 to 100 mw. It is a very simple modification.

I paid $50 for the IC-245 because it had a intermittent frequency synthesizer, which was traced to bad solder connections through the copper rivets soldered to the top and bottom of the board (before the plated through holes). Soldering a "Z" wire through the rivet and then soldering to the top and bottom trace made for a good electrical connection and the radio has worked great ever since. It was a big job to lift the synthesizer out of the chassis to get to the bottom of the board and all the rivets on the board, but the rig was inexpensive.

The big-brother version of the IC-245 is the IC-211, which is a base-station version of the 245. It has the same synthesizer rivet problem. Again, it is repairable, but it does take time to put the "Z" wires through the rivets, allowing good solder connections through the rivet and the top and bottom of the PC board.

Of course there is the king of the multimode transceivers, and that is the Yaesu FT-817, an all-mode, all-frequency, all-band, "triple A" radio in all respects. The only problem is that for a scrounger and swapmeet junkie it will be quite a while before this rig will be available at swapmeet prices. However, it features low-power operation and is small in size. It also has a lot of menu options for configuring the many features on the radio, which can be overwhelming. Even with a cheat sheet it can become somewhat difficult, as compared to older 2-meter multimode transceivers, which are essentially two- or three-function radios that even your grandson could operate time after time.

As you can see, there are all kinds of considerations when choosing a multimode radio, and I hope I have not confused you. In summary, the following points apply when you are considering buying a radio:

1. If it works and it's inexpensive, buy it. You won't be disappointed.
2. Be aware of the different dial displays—LCD, red LED, or green high-voltage displays. Consider what the effect will be when you are operating portable in sunlight on a hilltop.
3. If you have the time and the schematic is available, check out the power-cutting options on the radio you are considering.
4. If you can plug in the radio and give it a bench test, all the better.

What is my best IF system? Well, the FT-817 does rank up there for lots of reasons. However, when I get confused by the menu cheat sheets that I pack in the carrying case, I revert back to the IC-260 with a small cardboard shroud to shield the red display LED from sunlight.

Test Equipment

When it comes to test equipment to set the power to 100 mw, you could use a microwave power meter with a 30-dB attenuator. In my case, and again taking advantage of inexpensive surplus equipment, I found a Bird Wattmeter Model 6250 circa 1956. It reads power from 0 to 250 mw over the frequency range 30 to 500 MHz. I do, however, have a tendency to go overboard, and in this case it's the microwave power meters in my shack. I can calibrate the simple Bird power meter using my pair of HP 436 digital power meters and power heads for exacting work. But then what is a junk-box junkie doing with 436 power meters? I could use the power meter I recently found at our local swapmeet. It's an A-85-A antenna dummy load that uses three 47-type pilot lamps. Calibration is a little rough, though. You have to be a judge of power output as compared to lamp brightness. But then again, it only cost a buck!

73, Chuck, WB6IGP

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

Satellite News, VO-52 (HamSat), AO-51 Mode V/S, SSETI, and AMSAT Space Symposium

Since the last column in the Spring 2005 issue of *CQ VHF,* HamSat has been launched and named VuSat OSCAR-52, or VO-52; this year's Dayton Hamvention® has come and gone with its goodies and demos; a launch date for SSETI has been announced; and details are now available for the AMSAT Annual Meeting and Space Symposium to be held in Lafayette, Lousiana in October. We'll start off with details of VO-52.

VuSat OSCAR-52, or VO-52 (HamSat)

Launch: VO-52 (photo A)was launched on May 5, 2005 and was released for use within 24 hours after launch. Since that time, it has been checked out in most of its modes and mode combinations and has been given a clean bill of health. Several "firsts" are associated with this launch: (1) it is the first Indian amateur radio satellite; (2) it was launched as the first payload on a new Indian PSLV-C6 launch vehicle; and (3) it was the first launch from a new Indian launch site. The AMSAT India people are to be congratulated for successfully accomplishing these feats on the first attempt.

Capabilities: The 43-kg satellite contains two mode B transponders. Only one is in use at a time. The transponders are linear, inverting, analog transponders suitable for SSB and CW. Frequencies are:

Downlink Passband:	145.870–145.930 MHz	USB/CW
Uplink Passband:	435.280–435.220 MHz	LSB/CW
Beacon1:	145.936 MHz	Unmodulated Carrier
Beacon2:	145.860 MHz	CW Telemetry

Thus far I have not heard the CW telemetry. Evidently, it is turned on by the command station when in the area of the command station. The satellite uses a lithium-ion battery and gallium-arsenide-based solar panels. Transmitter output is listed as 1 watt. VO-52 has been placed in a low-Earth, polar sun-synchronous orbit (SSO) at an altitude of 632 × 621 km with an inclination of 97.8 degrees with respect to the equator.

Operation: The downlink sounds excellent, and many stations are reporting success with QRP power levels on the uplink. Portable operation has been successful with a simple receiver (Kenwood TH-F6A), a simple transmitter (Yaesu FT-817), and an Arrow Antenna. Operation from a typical mode B satellite base station is excellent. This should be a real winner. We owe AMSAT India a real vote of thanks for providing this excellent satellite for the amateur radio operators of the world.

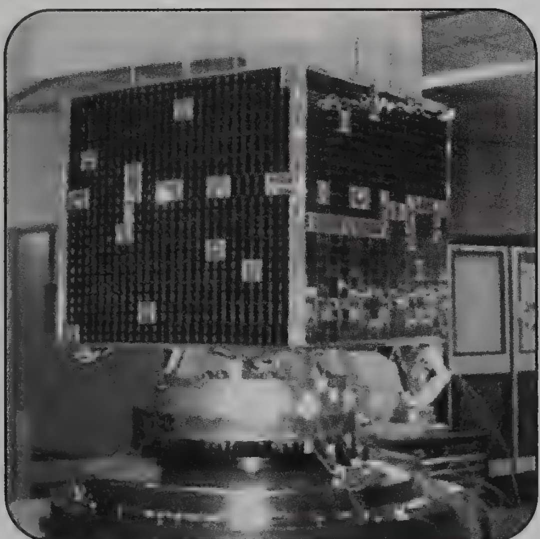

Photo A. VO-52 in the lab before launch.

AO-51 Mode V/S

Since the last column, considerable interest has been generated in mode V/S operation through AO-51. This combination was first tried about a year ago during early checkout. The beauty of this mode is operation with a VHF low-power uplink with minimal attention to Doppler and utilization of the relatively high-power S-Band transmitter (2.5 watts) on AO-51. Of course, Doppler is a real consideration on the downlink, but with FM operation and 5-kHz steps it is manageable. Reception of the downlink is easily accomplished with very simple antennas and down converters left over from AO-40. As a matter of fact, antennas larger than the ones described below are very difficult to keep pointed at a rapidly moving, low-altitude satellite. A typical IF for the down converter is a 2-meter FM HT.

Over the past year several periods of mode V/S operation have been provided. The most recent period started on June 17, 2005 and ended with Field Day 2005. Mode V/S was also scheduled during the Dayton Hamvention® this year, and KO4MA made several mode V/S demonstrations. Drew used a small corner reflector and a K5GNA down converter (both items available from K5GNA). Photo B shows this combination. I have successfully used the same down converter with a WØLMB dual-band patch feed (photo C). Just about every combination you can think of has been used by someone—e.g., small helicals, small dishes, small Yagis, etc. They all seem to work and

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Photo B. K5GNA down converter with corner reflector.

provide good results. Field Day 2005 will be the real mode V/S test and should set the scene for another popular mode.

SSETI Express

The Student Space Exploration and Technology Initiative, or SSETI, project has produced the first pan-European student satellite with the cooperation of students from 12 European countries. SSETI is jointly sponsored by the European Space Research and Technology Centre (ESTEC), European Space Agency (ESA), European universities, and AMSAT-UK. Quoting Sam Jewell, G4DDK, from his talk at the 2005 Dayton Hamvention® AMSAT Forum, "The SSETI Express mission is an educational mission that will deploy CUBESAT pico-satellites, take pictures of Earth, act as a test-bed and technology demonstration, *and function as a radio transponder for the rest of its mission duration.*"

Three CUBESATs will be launched from the SSETI Express "Mother Satellite": XI-V from Japan, University of Tokyo; UWE-1 from Germany, University of Wurzburg; and Ncube-2 from Norway. Each of these CUBESATs contains its own communications package.

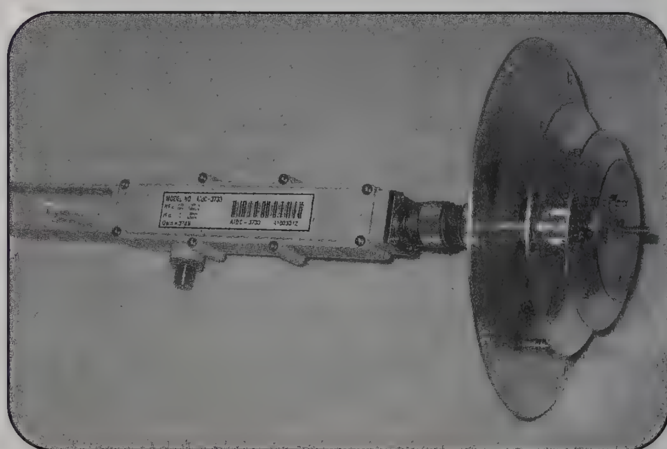

Photo C. K5GNA down converter with WØLMB dual-band patch feed.

Photo D. ARISS ground crew in Dallas at Hockaday School. Left to right: Keith Pugh, W5IU; Harold Reasoner, K5SXK; Tommy Davis, W5TCD; Bob Landrum, W5FKN; and Bob Dickey, K5HGH.

Two communications packages are part of SSETI Express: (1) a 437-MHz transceiver built by Holgar Eckart, DF2FQ, and (2) the S-Band package built by the AMSAT-UK team. These packages will relay 9k6- and 38k4-bits/sec data from the satellite to a ground station network of amateur radio operators and command stations. At the completion of the planned mission, the two packages will be configured as a mode U/S transponder for amateur radio use for the remainder of its life. This transponder will perform functions similar to the AO-51 mode V/S described earlier in this column.

As this colunm is being written, the finishing touches are being placed on SSETI Express in the Netherlands in preparation for shipment to Russia for launch on August 25, 2005. A backup launch date of August 26 has also been planned. A successful SSETI Express satellite will be a valuable addition to our flock of amateur radio "Birds."

AMSAT Space Symposium and Annual Meeting

The AMSAT Space Symposium and Annual Meeting will be held October 7–9, 2005 in Lafayette, Lousiana. The board of directors meeting will be held on October 6–7 at the same location. This year's meeting promises to be as informative as ever, with special attention paid to the progress being made on Project Eagle. Special consideration also should be given to attending this meeting due to the unique hospitality and food offered by the residents of Cajun Country, south Louisiana. If you have never experienced south Louisiana, this is your chance. In addition to the usual meetings and functions there is the Friday Night Shrimp Boil and the Sunday Morning Swamp Tour. I'm not sure where the satellites are in the swamp, but we will look for them! Everything is on the AMSAT web page, <http://www.amsat.org>, to make it easy to register for the symposium online. Sign up today and come on down to Cajun Country for the best Space Symposium yet.

Summary

We now have one new satellite, with another one on the way before the end of the summer. New ways of utilizing AO-51 continue to be discovered and explored. Equipping your station for the mode S downlink for AO-51 will put you in good shape for SSETI Express.

Please plan to attend the 2005 AMSAT Space Symposium in Lafayette and find out about all of the new and planned activity on amateur radio satellites while experiencing the unique hospitality and food in south Louisiana.

Nothing has been said so far in this column about the Amateur Radio in the International Space Station (ARISS), but this program continues. A record number of school contacts were made by the Expedition 10 crew, and the Expedition 11 crew may challenge that record.

Meanwhile, I recently participated in an ARISS contact for the Hockaday School Summer Program in Dallas, Texas and thoroughly enjoyed it, along with the other members of the ARISS ground crew from Fort Worth and Denton, Texas (photo D). See you here again next quarter!

73, Keith, W5IU

By April Moell,* WA6OPS

VHF+ PUBLIC SERVICE

Amateur Radio Support for Hospitals—A 25-Year Legacy

The First Steps in Supporting Hospital Communications

When a busy hospital loses its telephone service for any reason, it's a disaster for the staff and the patients. Admitting orders; requests for supplies, medicine, and blood; as well as calls to the Code Blue team depend on the telephone and paging systems.

In the Spring 2005 issue of *CQ VHF* I wrote about how hams stepped in 25 years ago when phones failed in a Fullerton, California hospital, eventually leading to the formation of an organization dedicated to backing up communications critical to patient care. All of us in the Hospital Disaster Support Communications System (HDSCS) firmly believe that hams everywhere must do more to meet the communications needs of their local medical facilities. This month I'll delve into the priorities and issues facing leaders of amateur radio emergency groups that take on this mission.

The Priorities

After the 1979 phone failure at St. Jude Hospital and subsequent ARES participation in a disaster drill there, six more hospitals in the county asked for ham radio support. What should the first priority be in providing that support?

A. Install an amateur radio station in each hospital.
B. Hold a class to get the hospital employees licensed.
C. Set up alerting plans for hospitals to get local ham help rapidly.

The correct answer is "C." Although it may seem counterintuitive, an installed ham station within a hospital is generally of limited use when phones fail and so should have a very low priority. Well-prepared hams with their own "go kits" are far more important. The only exception is hospital rooftop antennas; they can be quite helpful but should not be depended upon. This concept is so important that equipment preparedness for hospital support will be the topic of a future column.

Ham radio licensed employees in hospitals are not a complete solution, or even an adequate one. On average, we have needed a total of eleven hams for first response and relief in our single-hospital phone failure callouts, and sometimes lots more. Having a few hospital employees with tickets is far from enough, and when they're not at the facility in the wee hours, how will the hospital get help from ham radio operators?

Hospital employees all have important jobs already, and when they are doing them they won't be able to pay proper attention to the ham radio network. How much better it is to have a group of outside volunteer hams at the ready, as we do, to go into the hospital and be dedicated to performing communication tasks while the hospital folks go about their important patient care duties. Hospital hams may be helpful in non-emergency situations for liaison and education, if they happen to be interested. However, they should not be the primary amateur radio resource for their hospitals.

St. Jude Hospital had an installed HF station in the Rehabilitation Unit and one licensed employee (me) with portable 2-meter equipment in a desk drawer at the time of the 1979 phone outage. However, the stark reality was that the amateur radio response was sub-par back then, because there was no activation plan to bring in a sufficient number of communicators to assist the hospital. Although it was better than nothing, it was clear to me that there had to be a more reliable way for hospitals to get help from hams.

If, instead of a switchboard failure, an earthquake had occurred and severely damaged the hospital, a sufficient number of hams would not have thought to respond automatically. Even if they had, the hospital would not have known what to do with them. The use of amateur radio is not intuitive to non-ham hospital staff. It must be learned before the need occurs.

For the first Orange County hospital drill that included amateur radio, seven ARES members arrived at St. Jude Hospital prior to the start. All were set up in various units when the scenario began. Much was learned that day. The hospital staff members were certainly pleased with our communications capabil-

HDSCS Emergency Activations

68 Single-hospital telephone outages, due to
- **Switchboard/computer failures**
- **Severed cables (backhoes, etc.)**
- **Power failures and construction accidents**

7 Earthquakes
5 HazMat incidents
3 Wildfires
3 Floods
1 Mass-casualty incident
1 Area-wide phone outage

HDSCS has activated 88 times in response to communications failures affecting medical facilities. Of these, over three-fourths were single-hospital phone outages where the flow of important medical information was interrupted. If you think your ham group should only be planning to serve in widespread disasters such as hurricanes and earthquakes, please think again.

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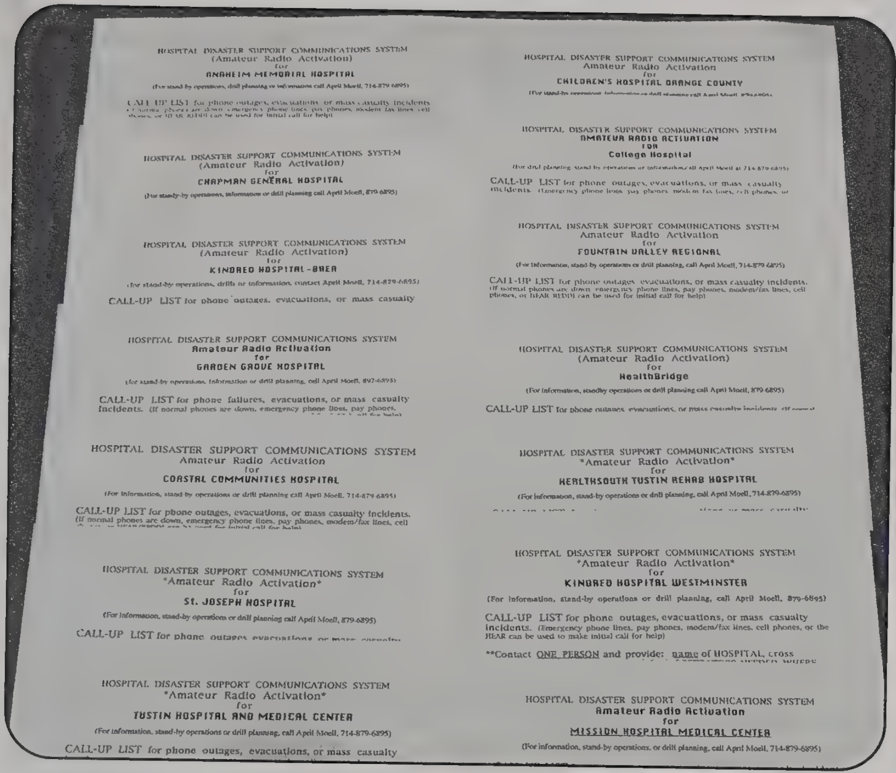

On display are Call-up Lists for 14 of the 33 hospitals currently served by HDSCS. Each hospital's list is tailored for its location and updated regularly. It includes both voice numbers and a unique pager code.

ities, but the drill did not teach them how to activate this group of communicators. The hams had not yet come to grips with how they would be notified if the real thing happened.

We realized this in our debriefing, and our first follow-up goal was to develop an activation plan for any localized hospital phone failure or mass-casualty incident. We knew that we couldn't wait, because the next emergency might happen at any time. With seven hospitals wanting amateur radio support and one of them asking "how will someone know we have problems in a major area wide disaster?" it was clear that we had our work cut out for us. A plaintive call on a repeater could never be a reliable callout procedure, certainly not one that could be written up in the hospital's formal disaster plan.

Direct Call-up Saves Vital Minutes

There are four crucial components to a successful activation procedure:

1. Direct access to hams
2. Redundancy
3. Regular review and update
4. Tests and drills

On a daily basis, hospital communications are time-critical and life-critical, so direct access from hospitals to the amateur radio emergency group is vital. Any "middlemen" waste precious time. I am aware of emergency groups in other parts of the country that are sponsored by local fire or law-enforcement agencies. The procedure that these groups tend to use, if they support the local hospitals at all, is to tell them to contact the fire or law-enforcement agency. In turn, these public-safety officials are supposed to initiate a callout of the hams.

This two-step process creates inevitable and unacceptable delays, even if the public-safety agency is prompt in responding to the hospital's request. A single-hospital phone outage is unlikely to become an officially declared disaster, even though it can be disastrous for individual patients in critical condition in that hospital. How will government agencies prioritize the phone failure, compared to a major fire or car chase that may be ongoing at the same time? In a mass-casualty situation, police and fire agencies may not be aware of any resulting hospital phone overload, and a ham response to the hospitals will not be near the top of their action lists.

Operating within the ARRL ARES (Amateur Radio Emergency Service) structure has made it a one-step process for hospitals to contact HDSCS directly. We know that this saves valuable time. In one phone failure, first HDSCS responders had been on site providing communications for 30 minutes, with more on the way, when the Orange County Communications Center called to alert me about the same outage. I was glad to have the backup of the Communications Center's call, but the hospital's ability to directly alert us had saved priceless time.

An alerting plan is not adequate without redundancy in both the hams to be called and the methods to call them. No person is available every hour of every day, yet I have had hospital personnel from outside my area tell me, "The leader of the Podunk ham club gave me his card and said if I ever had a communications problem to just call him." Do you really think that's a plan? What if the ham's phone line is busy or the hospital gets his phone machine? Worse yet, what if the hospital calls two years later and finds out that the ham contact is deceased? (I've heard that this actually happened in another state!)

Every hospital supported by HDSCS is given its own Call-up List of three persons for daytime/weekdays and three for evening/weekends. Depending on availability, the same hams might be on both day and evening lists. In every case, the persons on the Call-up List are normally available by phone at that time of day and are well versed on the activation procedures of HDSCS. They are not necessarily first responders themselves.

After a member on the Call-up List receives an emergency call from a hospital and obtains information on the emergency, it is up to him or her to immediately initiate an appropriate activation of the system. Hospital staff cannot take the time to make additional calls for us after the first successful one. Upon being called, the member first contacts one or more of the coordinators.[1] He or she then responds to the hospital, calls other members to do so, or establishes net control, as directed by the coordinator.

Names on the Call-up Lists are a mix of coordinators and experienced members. All are knowledgeable about the information that must be obtained from the calling hospital, and they are very familiar with how the amateur radio team functions. Because Orange County is a large area, the Call-up Lists reflect the

geographic distribution of the members. Wherever possible, persons on each hospital's list are within a few minutes' drive of the facility.

You are probably wondering how HDSCS is contacted by a hospital if its phones are out. Depending on the nature of the outage, there are several effective ways. When switchboard equipment fails and underground lines are intact, HDSCS frequently is contacted from pay phones. Many hospitals have a few emergency phones that are separate from the main system, and/or a special emergency system that takes over the trunks when the normal switchboard goes down. Although such systems have only a very limited number of lines, they are adequate to activate the amateur radio team. Fax and modem lines separate from the main phone system are another possibility.

When underground cables are severed, affecting all lines to and from the hospital, cell phones have been used by hospital staff to call for help. An example was the 16-hour activation at Tustin Hospital last year.[2] In another instance, the employee was only able to get out the name of the hospital before his cell phone's batteries failed. However, that was enough to get our response going. Orange County has a hospital radio/data system called HEAR/ReddiNet, and any hospital can use it to contact another hospital, which could in turn alert the hams using its Call-up List. The same relay alert can be done via the hospital's paramedic base radio, if one is present.

Pagers are also an important part of the HDSCS activation system. Even though each hospital has at least three member voice numbers to contact, day or night, it is possible that all might be busy or not answered by a person. This was the case when West Anaheim Medical Center lost phones on the morning of Field Day 2004, when most members were away from home.[3] In a major mass-casualty incident or potential evacuation situation, hospital staff may be unable to take the time to call numbers until an answer is received, and then give details to a member. For both of these circumstances, our hospitals have a pager number to call, which brings a full response from HDSCS.

For pager response, each hospital is assigned a unique three-digit number that the caller inputs instead of a return phone number. The three-digit number immediately identifies the facility in trouble, without the page recipient having to recognize the phone number or call it back. When a three-digit page is received, we attempt to contact the hospital for information on the emergency. If we get through, we get the details we need. If we can't get through, we go into a full response anyway.

An important ongoing task is to maintain all the hospitals' Call-up Lists. Members often change work, home, cell, and pager numbers, and these changes must be given to the affected hospitals immediately. The flip side of this is that our contacts at the hospitals undergo constant change, too. As HDSCS coordinator, I must keep checking to make sure that the appropriate contact person is aware of the Call-up List and where it is kept within the facility. When I e-mail or fax an updated list to any hospital, I have to follow up and verify that it gets to key personnel in the facility and into the hospital's Emergency Procedures and Disaster Manual.

Our activation plans would be worthless if the hospitals did not utilize them. In the chaos of a disaster, they must remember to call us and know how to do so. The standardized Hospital Emergency Incident Command System (HEICS), used by all Orange County hospitals for mass-casualty incidents and other situations where an emergency is declared, calls for the Hospital Communications Officer to initiate an activation of amateur radio communications support. However, a one-hospital switchboard or trunk-line failure rarely results in a formal HEICS activation.

To ensure that hospitals practice calling hams, we include our activation in the mass-casualty drills which include every hospital over the course of a year. Rather than have hams in place within the hospital at the start of the drill, they are prestaged nearby. Each hospital must go through its call-up procedure before the hams enter and join the net. Besides ensuring that the hospitals are familiar with the location of their Call-up Lists and the need to use them, our members have the valuable experience of coming into the hospital and setting up as the simulated emergency is in full swing.

Core Teams Provide Automatic Response

A tornado, earthquake, hurricane, or other major disaster may disrupt all telephone communications over a wide area, making it impossible for hospitals to call hams for help. Hams cannot assume that city and county agencies will somehow know which hospitals are in need of help in such cases. No news is not necessarily good news, and hospitals must not be afterthoughts in any amateur radio disaster response.

Besides being on Call-up Lists, most HDSCS members are what we call Core Team Responders. They have made a commitment that HDSCS is their primary amateur radio responsibility in a widespread disaster. They identify the hospital or hospitals closest to their home and work locations, and agree to respond and check on the status of those facilities immediately upon learning of the disaster, without waiting for a call.

An earthquake, tornado, or hurricane is its own alerting system. It shouldn't be necessary for hospitals to call us when one of these occurs, and it isn't. Upon feeling the ground shake, HDSCS members automatically get on the air, begin a net, and check on their closest hospitals. Similarly, when HDSCS members learn of flooding or wildfires within or close to Orange County, the group activates a net and checks on the hospitals most likely to be affected.

In our 25 years, rapid automatic response has proved vital in several emergencies. After the twin Landers (magnitude 7.3) and Big Bear (magnitude 6.4) earthquakes that occurred during Field Day 1992, HDSCS members immediately left their homes and Field Day sites to check on 34 hospitals in the county. We determined the status of most of them in less than 90 minutes and all of them within three hours. Member Gary Holoubek, WB6GCT, arrived at Buena Park Doctors Hospital to find it completely dark because the emergency generator had started and then failed. All of the facility's phones were down, too. Besides providing emergency communications, we obtained a priority response from Southern California Edison.[4]

Immediate Core Team response was important during the Laguna firestorm of 1993. One hospital asked for support and told of difficulty getting through to other hospitals in that part of the county. We responded to that one and also to three others that were eventually affected, saving valuable time. Moments after the 2002 Placentia Train collision took place, we were aware of the disaster and the location. We didn't wait for hospitals to call or page us, so when some of our hospitals called after getting their own Emergency Command Posts set up, our

HDSCS communicators were already heading into these hospitals or parking their vehicles, ready to go in.[5]

Rounding Up the Hams

An up-to-date roster of trained and prepared responders is the most important tool for activation of members in a call-up response. Just jumping on a repeater and trying to get anyone you can, as I had to do in 1979, might ultimately bring some help. However, it carries the risk of attracting some who are neither prepared nor suitable for communications in a hospital environment. Hams on the HDSCS roster have agreed to be hospital responders, to keep prepared, and to participate in regular training and drills. Even if your community does not have a specialized hospital response group such as ours, I recommend that there be a special list of hams identified for response to hospitals.

HDSCS members are encouraged to monitor our repeaters. A call there will usually yield some members who can respond immediately. Typically, though, more are needed and we turn to the roster. Besides a complete printout of members with home, work, cell, and pager phone numbers for each, our Coordinators have special First Wave lists that identify the eight members who should be called first for each hospital, in daytime or evening. Because the hams on these lists are the ones likely to be closest and most available to the facility in need, our response time is greatly improved.

As with the hospital Call-up Lists, our rosters and First Wave lists undergo constant revision. HDSCS members take our mission seriously and promptly advise coordinators of any changes in phone numbers and work schedules. Roster updates are disseminated to all members via e-mail as they come in.

In a Core Team response after an area-wide disaster, HDSCS members come up on our designated frequencies and advise net control as to which hospitals they are responding, based on their proximity at the time. If net control determines that some hospitals are being "left out" while others are "overcovered," responders are immediately reassigned as needed. The primary goal in the initial response is to ensure that all of our served hospitals are provided with a link to the outside world until their normal communications can be re-established.

If amateur radio operators wish to be viewed as serious about support to any agency, then they must be prepared at home and in their vehicles. An emergency communicator should not have to go home to grab gear out of the shack before responding to an assignment. HDSCS members perform equipment and personal preparedness such that they can make a Call-up or Core Team response immediately from their place of employment or from home.

Our family obligations come before our amateur radio responsibilities, of course. Hospitals have the same issues when calling in their own employees for emergency service. Therefore, we have found that they understand our occasional need to bring children or other family members with us on Core Team responses. Of course, having more than one HDSCS member in a family is a definite plus!

If a hospital in your area had a phone failure right now, what would staff members do? Would they know how to call for amateur radio help? Would they even think about amateur radio as a source of communications, both from unit to unit within the facility and from the hospital to their physicians and suppliers?

Amateur radio operators want our hobby to be known as a national resource and we like to wear T-shirts that say "Amateur Radio, When All Else Fails." However, we are no resource at all if important local agencies such as hospitals don't know that we can help and don't know how they can access our services. We aren't a viable resource if we don't plan ahead for how we will activate rapidly and serve these agencies.

With regular contact and activation procedures in place, amateur radio will be of service to hospitals long before all else fails. That's important, because when it comes to patients' lives and well-being, if hams wait until all else fails, they have waited too long.

Notes

1. At present, there are seven coordinators of HDSCS, including April Moell, WA6OPS, and six assistants. Total membership is approximately 75.

2. Details of this activation are at <http://members.aol.com/emcom4hosp/tustin04.html>.

3. Details of this activation are at <http://www.arrl.org/news/features/2004/06/30/1/?nc=1>.

4. Details of this activation are at <http://members.aol.com/emcom4hosp/history.html>.

5. Details of this activation are at <http://members.aol.com/emcom4hosp/metro2.html>

By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Bouncing VHF Signals Off "Shooting Stars"

Several times each year VHF enthusiasts are presented with the exotic operating opportunity created by shooting stars. The intense ionization caused by a meteor's demise as it burns its way into our atmosphere can be enough to reflect or refract VHF radio signals, making possible radio communication between two stations beyond line-of-sight, if only for a very short moment.

Reflecting VHF radio signals off meteor trails during one of the year's annual meteor showers is an activity that has been enjoyed for decades. Now new methods and techniques are being developed and explored using modern computing power. The newest tools even allow radio contact during periods outside the major meteor showers.

It is typical during major meteor showers for hundreds of two-way contacts (QSOs) to be made. I've even had the joy of making a few quick contacts between my meager station (a vertical mobile antenna tuned for 6 meters, with 100 watts on SSB) and stations up to two states away. This was accomplished during the *Leonids* meteor shower a few years ago. With the newest software tools, and with good equipment and a good antenna, along with prearranged schedules, many amateur radio weak-signal communicators make quite a few contacts all year long.

Most schedules in North America between VHF meteor-scatter DXers are for SSB QSOs. When using SSB, a 15-second sequence is standard, where the westernmost station calls first, and the rest of the minute is spent listening for the reply from the called station. Most often a QSO is completed on a long burn lasting several seconds. However, because most meteors only last from close to one-quarter second to a couple of seconds, there's usually not nearly enough time to get much information through on SSB.

This is overcome by using high-speed CW. If you tried to keep a 2-meter meteor scatter schedule with a station some 1000 miles away, you might hear five to ten short "pings" (a burst of radio propagation caused by the rapidly formed and short-lived meteor-trail ionization) lasting anywhere from a tenth of a second up to two seconds in length. A ping under a half of a second would be absolutely useless on sideband. Enter high-speed CW. With HSCW you could realize a speed of 2000 letters per minute (2000 lpm). In that same half-of-a-second ping 16 letters could be propagated to the receiving station. That is enough for a complete exchange and signal report! High-speed CW is more commonly called high-speed meteor scatter, or HSMS.

To ensure that only one station is transmitting at a time during a schedule, HSMS stations in North America transmit on alternate minutes. Typically, the westernmost station transmits on the even-numbered minutes while the easternmost station transmits on the odd-numbered minutes. During a minute, a meteor may fly between the two stations and briefly reflect a VHF radio signal. The QSO is completed when both stations have heard each other's callsign, a signal report (or some other piece of information), and the final "Roger." On 2 meters schedules usually last a half hour to one hour. I'll dig deeper into this mode later on in the column.

Meteor Scatter Mode

Meteors are particles (debris from a passing comet) ranging in size from a speck of dust to a small pebble, and some move slowly while some move fast. When you view a meteor you typically see a streak that persists for a little while after the meteor vanishes. This "streak" is called the "train" and is basically a trail of glowing plasma left in the wake of the meteor. Meteors enter Earth's atmosphere traveling at speeds sometimes well over 158,000 miles per hour. The trains can last from several seconds to several minutes.

Meteor-scatter propagation is a mode where radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E* layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports a 60-second refraction on 6 meters might only support a 1-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

A great introduction by Shelby Ennis, W8WN, on working meteor scatter is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. OZ1RH wrote "Working DX on a Dead 50MHz Band Using Meteor Scatter," which is a great working guide <http://www.uksmg.org/deadband.htm>. W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

Perseids Meteor Shower

One of the most reliable yearly meteor showers is the *Perseids*. This shower, like other meteor showers, is named after the constellation from which it first appeared to have come. The shower's constellation is Perseus, which is located near Cassiopeia. *Perseids* favor northern latitudes. Because of the way Comet Swift-Tuttle's orbit is tilted, its dust falls on Earth's Northern Hemisphere. Meteors stream out of the constellation Perseus, which is barely visible south of the equator.

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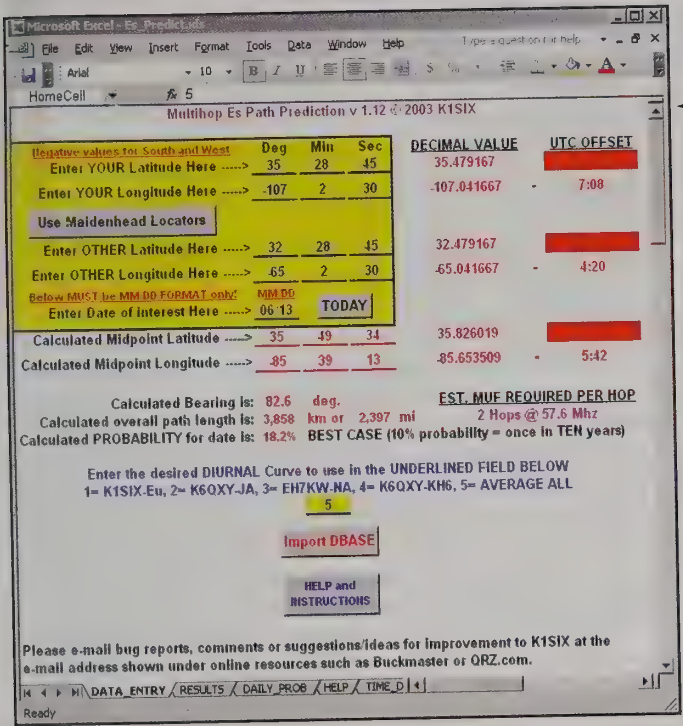
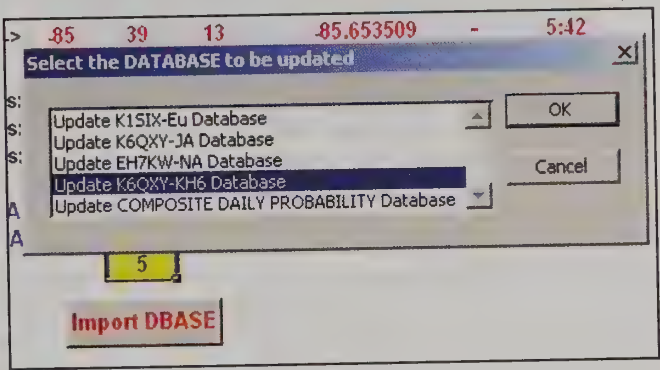


Bob Mobile, K1SIX's multi-hop sporadic-E prediction tool. With this spreadsheet application you might be able to increase your success rate by discovering possible windows of opportunity for establishing a QSO between you and a selected grid square.

Illustration of importing the most recent data into the database tables. Once you download the updates, place them into the default location for documents (typically in your Documents folder). Then select the Import button, which results in this dialog. Select each option, one at a time, to import that database.



Lewis Swift and Horace Tuttle, Americans working independently, discovered a comet in August 1862. Three years later Giovanni Schiaparelli (of Martian "canali" fame) realized it was the source of the August *Perseids* meteors. The comet, known now as Comet Swift-Tuttle, leaves a trail of dust that Earth passes through during August.

This year the shower will be active from July 17 through August 24. The peak is expected to be around August 12, between 1700 UTC and 1930 UTC. The number of visual meteors is expected to be about 100 per hour. It is possible, using high-speed CW, to realize a higher hourly rate, since many meteors that are not visible might contribute to the ionization necessary for long-distance contacts.

There was a prediction that last year's *Perseids* meteor shower would produce a "meteor storm," with hundreds of meteors per hour. This prediction did not pan out. However, some researchers are still suggesting, based on careful analysis and modeling, that this year or next might see a return of the primary peak with a high rate per hour.

The *Perseids* shower begins slowly in mid-July, featuring dust-size meteoroids hitting the atmosphere. As we get closer to August 12, the rate builds. For working VHF/UHF meteor scatter this could prove to be an exciting event.

The best time to work the *Perseids* VHF/UHF meteor scatter in North America is during the hours before dawn, as early as midnight, but more likely peaking after 2:00 AM until about 5:00 AM local time.

The characteristic *Perseids* burn is bright white or yellow and typically lasts less than a half second. The brighter meteors usually leave a persistent train or "smoke trail" that lasts a second or two after the meteor has vanished. This is not really smoke at all, but rather ionized gas created by the meteor passing through the atmosphere at tremendous velocities. It is this trail that potentially reflects the VHF radio signal.

Setting Up a *Perseids* VHF Schedule

If you have a reasonably powered computer with a sound card you could try your hand at using a digital mode for meteor scatter during the *Perseids* shower. Visit <http:// www.vhfdx.de/wsjt/> to obtain your copy of the WSJT computer program. WSJT stands for "Weak Signal communication, by K1JT." This program was created by Joe Taylor, a 1993 Nobel Laureate in Physics for the discovery of a new type of pulsar, a discovery that has opened up new possibilities for the study of gravitation. The program currently supports four principal modes, two of which primarily are useful for weak-signal communications via the short pings from meteor trails. These two modes are FSK441 and JT6M. JT6M is especially optimized for working meteor scatter on 6 meters, while FSK441 works well up into the higher VHF bands.

With either of these modes, the QSO exchange is much like other digital modes, where the communication is tex-

	C	D	E	F	G
	LAST UPDATED ------->	21-Aug-04	21-Aug-04	25-Aug-04	21-Aug-04
	FILENAME.dat ------->	SIX_Diur	JA_Diur	EA7_Diur	KH6_Diur
:L	DIURNAL DATA x DAILY PROB	K1SIX-Eu	K6QXY-JA	EH7KW-NA	K6QXY-KH6
	0.0000				0.0000
	0.0000	0.0005	0.0000	0.0000	
	0.0010				0.0058
	0.0001	0.0000	0.0000	0.0012	
	0.0000				0.0000
	0.0008	0.0097	0.0000	0.0043	
	0.0010				0.0058
	0.0013	0.0166	0.0000	0.0074	
	0.0019				0.0116

When you first run the Es *prediction tool, check that you have the most recent data imported. Look at the dates in the top row. If you don't have the most recent data (the most recent is always from the last summer season), you may download it from K1SIX's support site (see text for URL) and easily import the data.*

tual. WSJT is a high-duty cycle mode, so you must ensure that you set up your equipment properly (don't overdrive your amp, keep an extra fan on the transceiver, etc.). Once you have everything set up for operation, announce yourself on one of the scheduling sites on the Internet. Three of these are <http://www.pingjockey.net/cgi-bin/pingtalk>, <http://www.meteorscatter.net/>, and <http://dxworld.com/vhfsked.html>.

Most meteor schedules will run for 30 minutes, but they can be shorter or longer. You and the other operator must agree beforehand so that you are coordinated. Remember to follow the standard format, where the westernmost station transmits the call for the first 30 seconds while the other station listens. Then the other station transmits for the next 30 seconds. Each minute is broken in two parts, 30 seconds each part. The station in the most western end of the path will transmit during the first 30-second period. The most eastern station takes the second period to transmit. This requires that both of you are set to the same time, exact to the second.

When it is your turn during the minute, you would transmit something such as "KD7QKT NW7US KD7QKT NW7US KD7QKT NW7US." The idea is to keep things short and sweet. At least halfway into your 30-second period you might break your transmission for a pause, to see if there is a meteor burst that your schedule partner wants to take advantage of. A pause like this, of a second or two, gives the other station a chance to transmit data, if possible. Of course, you might pause a few times during each period.

What do you exchange? As with any mode of operation, you exchange callsigns, some type of information or report, and a confirmation of the same. When a station copies both calls, that operator sends calls and report. If both calls and a report are received, that station sends the report and a "Roger." When both get a pair of "Rogers" (this might take several exchanges) the QSO is officially complete. However, the other station will not know this. Therefore, it is customary to then send "73" to let the other station know that it's complete, even though the "73" is not required for a complete QSO. Mobile, portable, and DXpedition stations normally never send 73 unless they're shutting down, but instead return to calling CQ immediately after the exchange of Rogers. Full details are published at <http://www.qsl.net/w8wn/hscw/papers/hscw-sop.html>.

Can You Listen In?

It is possible for you to listen for meteor-scatter bursts. Some even hook up special software to graph the meteor-shower radio activity. You may also "tune in" via the Internet. Three sites that provide an opportunity to listen in are the Roswell, New Mexico forward-scatter radar at <http://science.nasa.gov/audio/meteor/meteorburst.m3u>, the Huntsville, Alabama forward-scatter radar at <http://science.nasa.gov/audio/meteor/forward-scat.m3u>, and the Naval Space Surveillance Radar in Roswell at <http://science.nasa.gov/audio/meteor/navspasur.m3u>. The best time to monitor is just before local dawn at these locations on August 13.

However, let's look at how you might listen in with your own radio. One method is to tune an FM radio to a clear frequency that is also known to be the frequency of a radio station far beyond line of sight. You can also use other frequencies, if you know of a transmitter located hundreds of miles away, licensed on that frequency. The frequency range most suited to meteor scatter lies between 40 and 110 MHz. It is most effective to select stations that are north or south of you.

You can then listen and record each meteor burst, identified by the quick burst of radio signal on that frequency. If you are tuned to an FM station channel and suddenly hear a burst of voice or music, you know that you are hearing that distant station via meteor scatter. Or, if you are tuned to a TV station, you might hear the buzz of the TV signal.

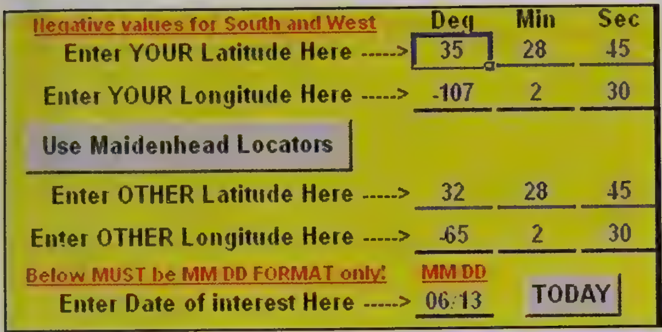
You might try hooking up your receiver to your computer to record the pings with software. Two very useful software tools used for this purpose are the Meteor DOS and Colorgramme. Visit <http://radio.meteor.free.fr/us/main.html> for details and download information. These are free specialized software programs used to detect and record radio signal echoes produced by meteor-shower pings.

Finally, check out the Audio Gallery of Radiometeor Events at <http://www.amsmeteors.org/audio/index.html>. This site offers actual recordings of radio energy created by the meteors as they burn up.

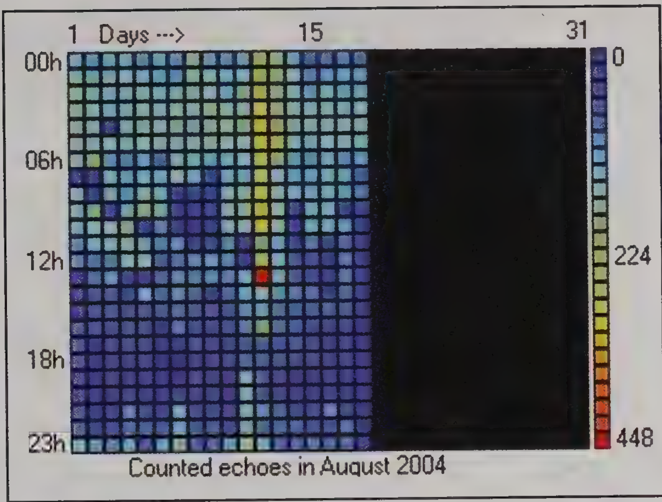
Other Meteor Showers of Summer

Look for the *Draconids,* a primarily periodic shower which produced spectacular, brief meteor storms twice in the last century, in 1933 and 1946. Most recently, in 1998, we saw a moderate peak of a ZHR (zenith hourly rate) reaching 700. This was due to the stream's parent comet, 21P/Giacobini-Zinner, returning to perihelion. The next return of the comet is in mid 2005. This year's peak is expected to occur on October 8 at 1600 UTC. The shower should be active from October 6 through October 10. The *Draconid* meteors are exceptionally slow-moving, a characteristic that helps separate genuine shower meteors from sporadics accidentally lining up with the radiant. This is a good shower to work meteor-scatter mode, since we might see storm-level activity this year.

Another expected shower is the *Orionids,* active from October 2 through November 11, peaking on October 21



The main setup section of the main screen (first tab). This is where you enter your location, the distant station's coordinates, and other information needed to run the prediction. You can use grid squares or enter the latitude and longitude manually.



Using the Meteor DOS and Colorgramme programs you can produce a graph of your meteor-scatter reception with results like this example. This example is from the Perseids *meteor shower in 2004. Note the one hour when the echo rate reached 448 per hour!*

at 2000 UTC. The hourly rate could reach about 60 meteors per hour.

For more information, take a look at <http://www.imo.net/calendar/cal05.html>. Also check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and up-coming showers.

Sporadic-*E* Update

The season up until press time has been somewhat slow in North America. However, some very nice openings have been reported. Activity on 6 meters early in the season generated quite some excitement. Reports have been made of openings between New Mexico and stations as far away as 1800 miles that lasted from before 7 AM local time to nearly midnight. Other long openings on the East Coast and over other paths have been reported.

How have your sporadic-*E* experiences been this year? How does this year compare with previous seasons? Send me a note with your observations. I'll compile a summary for the next issue.

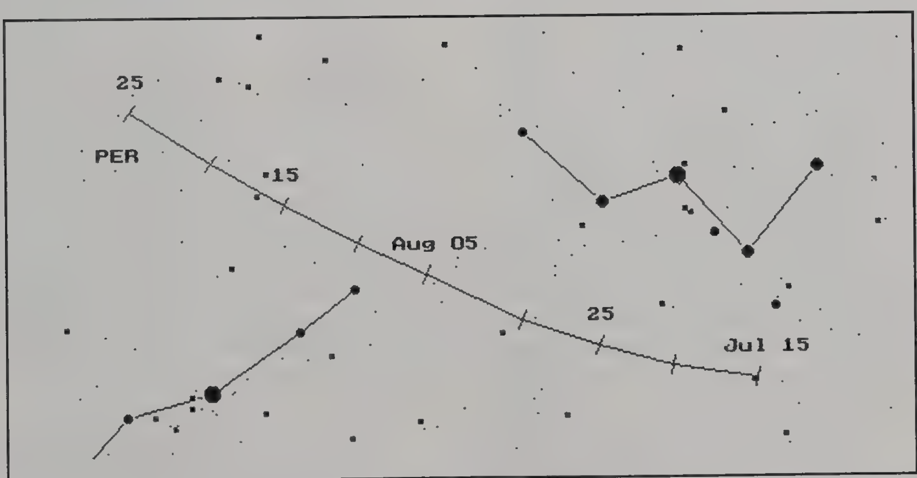
Check Out the Sporadic-*E* Prediction Tool

I've taken a look at Bob Mobile, K1SIX's Multi-hop Es Prediction Application <http://k1six.com/EsPredictApp.htm>. This tool has some interesting potential. This spreadsheet application is useful for mid-northern latitude paths where both ends are above five degrees north latitude. Using tables of data compiled from previous seasons, you can make a probability prediction of an opening between your station, and a grid square out beyond a single-hop. The prediction specifically is for the probability for multi-hop sporadic-*E* propagation of 50 MHz during the Northern Hemisphere peak *Es* season (May through August).

K1SIX writes, "*Es* may not be quite as 'sporadic' as once thought. In fact, it appears that there are certain repeatable characteristics and cyclical qualities to this mode of propagation that, once understood, may lead to a much higher probability of successful communications links across very large distances (up to and possibly beyond 10,000 km at 50 MHz!) in the VHF range. Who knows? With the proper 'tools,' some of these events may become quite predictable." Bob created this spreadsheet application as an attempt at compiling QSO data into tables that can be used to calculate the probability and best times for mid-northern latitude 50-MHz multi-hop *Es* paths between the two points entered by the user.

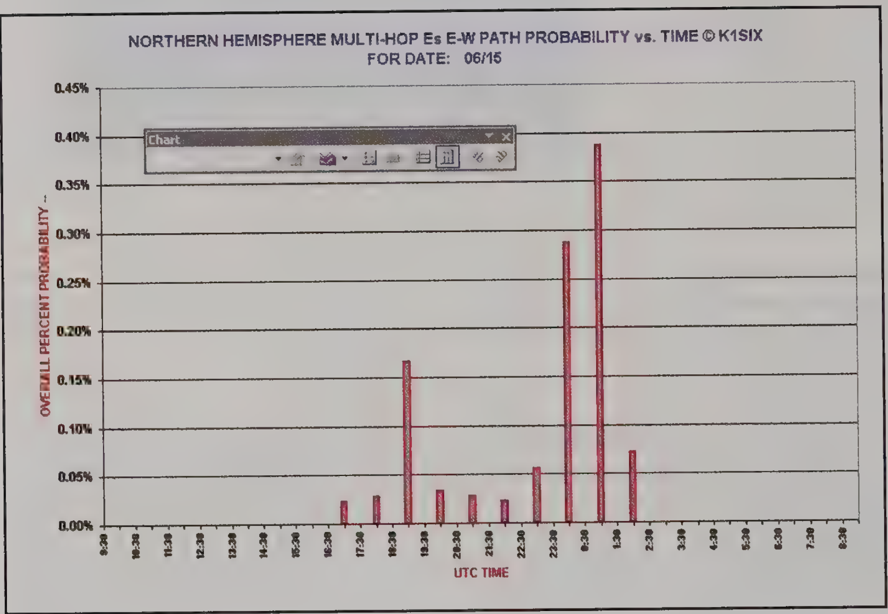
Bob's application includes five tables (databases) that must be updated each year. His website contains the latest tables, and the tool has a simple import utility. All of these five tables are updated at some point after the end of each summer *Es* season.

To use the application, you open the spreadsheet and enter in critical items of data under the DATA_ENTRY tab. This is considered the main screen for the tool. The first step is to enter your location either by providing your latitude and longitude using negative degrees for south latitudes and west longitudes (for instance, I am in Washington State, so my longitude is –122), or by pressing the "Use Maidenhead Locators" button to use grids for entry (in my case, CN87MQ). When using



The Perseids *meteor shower radient sky chart. (Source: IMO)*

An example of the results from a prediction. Note that in this example the QSO would require three E-layer *hops (*Es *hops) at 64 MHz (MUF, maximum usable frequency). The probability is bleak, but as shown in the other results example, you are looking for "windows" of possibility.*



A chart of times that indicate the most probable time for a multi-hop Es *opening between the two grid squares you've entered for prediction. In this example run, the most probable time on June 15 would be at 0100 UTC.*

grids with two- or four-character input, the program will force the entry to the center of either the field or the locator. Input error checking is included.

Next you need to enter the date of your prediction. If you don't provide the date, the calculations will fail. Enter the date in MM/DD format. Finally, a diurnal database option between 1 and 5 must be entered into the data entry zone just above the Import DBASE button. An entry of 5 will average all of the diurnal database table data to give a composite model.

You can change any of these parameters to see how the results change. Depending upon location entered, you may see a better fit using a particular model. However, some of these diurnal models may not be statistically significant until a larger sample is gathered. This is one of the reasons a DBASE Update and Import Utility was designed.

The results of the computation show up in three places. The first is under the RESULTS tab. This is probably the most interesting. The chart displays the overall probability for the path at 30-minute increments of UTC time on the X axis versus percent probability on the Y axis. The second result location is under the DATA_ENTRY tab and is colored as red data, which includes the equivalent decimal degrees for all entries or computations, UTC offset time presented unrounded to minute resolution (may be helpful if tracking an opening someone else is reporting; assume westward motion of approximately 17 miles per minute) for all entries or computations, the location of the path midpoint along the Great Circle Arc, the true bearing, the short-path distance, and the probability of a multi-hop event occurring for the particular date of interest. Finally, the third place to find results of this prediction tool is under the DATA_ENTRY tab as pink data items which include the estimated number of *E*-layer hops required for the path of interest and the estimated MUF for each of the hops, assuming an operating frequency of 50.1 MHz. No attempt is made to account for cloud-to-cloud or ionospheric tilting. This information may be useful in determining the probability of a multi-hop path for a given range.

Although the probability values are small (and likely accurate), this is all about picking the best times and dates for a particular 50-MHz path of interest. Therefore, changing the dates and experimenting to achieve the "best numbers" will likely pay off.

The Solar Cycle Pulse

The observed sunspot numbers from March through June 2005 are 24.8, 24.4, 42.6, and 39.6. The smoothed sunspot counts for September through December 2004 are 37.6, 35.9, 35.4, and 35.3, continuing on the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from March through June 2005 are 90.0, 85.9, 99.5, and 93.7. The smoothed 10.7-cm radio flux numbers for September through December 2004 are 103.7, 102.1, 101.5, and 101.3.

The smoothed monthly sunspot numbers forecast for August through October 2005 are 19.4, 17.9, and 16.5. Note how these predictions are somewhat higher than the predicted values I gave for May through July 2005, in the last issue of this magazine. The current cycle does seem to have a more gradual decline slope than predicted, so the adjustments are tending to be higher each iteration. The smoothed monthly 10.7 cm is predicted to be 80.6, 78.8, and 77.4 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A* index (*Ap*) numbers from September through December 2004 are 13.6, 13.5, 14.1, and 14.8. The monthly readings from March through June 2005 are 12, 12, 20, and 13.

(Note that some of these reported indices are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Feedback, Comments, Observations Solicited!

I look forward to hearing from you. Share your summer weak-signal results. Do you have questions? Please drop me an e-mail or send a letter. If you wish to see real-time solar and terrestrial information, visit my propagation center at <http://propagation.hfradio.org>. If you have a WAP/WML phone or handheld device, browse at <http://wap.hfradio.org>. Happy weak-signal hunting!

73, Tomas, NW7US/AAA0WA

CQ's 6 Meter and Satellite WAZ Awards

(As of July 31, 2005)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IK0PEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Antenna Measurements and Ranges

This time we will cover some of the different ways of making antenna measurements, along with the advantages and pitfalls of each.

For 30 years now the Central States VHF Society has been holding an antenna contest during its annual conference. I have been doing the microwave portion of this contest for nearly 20 years. During a typical event we measure 100 to 125 antennas on all ham bands between 50 MHz and 47 GHz, and I hope to add 76 GHz for it this July!

Photo A. The 50-MHz antenna range at the 2003 Central States VHF Society Conference, which was held in Tulsa, Oklahoma.

CS VHFS 2003

RF Power—Hewlett Packard power meter and a test antenna. This is possibly one of the simplest ways to measure antenna gain. For the microwave bands the source needs to be running at least 100 milliwatts with a high-gain antenna. The receive end uses a standard RF power meter. The older HP 431s and 432s can be used. The newer 435s and 436s are nice, though, when they are available. Power meters by Marconi, Boolton, and others may also be used.

First connect the power meter to your reference antenna, hold up the antenna, and measure the power. Next connect the test antenna and take the reading. If the test antenna collects 3.2 dB more RF power, then the test antenna has 3.2 dB more gain than the reference antenna. You quickly realize the most important part of this setup is the reference antenna, as you know the gain of it.

Advantages

1. Direct readout of gain in dB
2. Simple

Disadvantages

1. Poor sensitivity; a lot of power is needed.
2. No frequency selectivity. The antenna may be picking up TV stations, etc., and giving a bad reading.

Photo B. The Hewlett Packard 435A power meter. Using a power meter and a test antenna is possibly one of the simplest ways to measure antenna gain.

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e-mail: <wa5vjb@cq-vhf.com>

Photo C. The HP 415E is a tightly tuned 1000-Hz audio meter.

1000 Hz—HP 415R SWR meter with diode detector and external speaker. For many years, the 1000-Hz method was the most commonly used antenna measuring technique. Perhaps you have noticed that many of the RF signal generators have a 1000-Hz AM modulation switch. The signal generator is connected to a source antenna and set to the desired frequency; modulation is set to 1000 Hz AM. At the receive end, both for reference and later, the test antenna is connected to a 1000-Hz AM indicator. Just a simple diode detector is connected to the test antenna. The 1000-Hz indicator and the level of the 1000-Hz audio are measured with a meter not unlike the VU meters we had on tape recorders. You don't have to use a signal generator. Marc, WBØTEM, has even been known to use a Kenwood TS-700 2-meter rig in the AM position as his source for the Central States VHF Society's 2-meter antenna range.

A diode detector typically has a poor SWR, so a 6-dB—or better yet, a 10-dB— attenuator is added to the input of the diode detector. The resistive losses mean a lower signal-to-noise ratio. Therefore, sometimes we may use a 6-dB attenuator when we really should use a 10- or 20-dB pad, but then we need the extra signal. The pad also provided a DC return path for the detector diode.

On the higher bands it is often difficult to find coaxial diode detectors. Fortunately, the HP 415s are quite happy with waveguide detectors. I have also used WR-90 to WR-10 style waveguide mixers as my 1000-Hz detectors.

The diode detector recovers the 1000 Hz AM right at the antenna. In a way, this is just a glorified AM crystal radio with an accurate measurement off the audio level. The HP 415, or one of the many similar units made by Marconi or Narada, contains a tight 1000-Hz filter, so other detected signals are filtered out with a simple audio filter.

Advantages

1. 20–30 dB more sensitive than a simple power meter.
2. Much fewer QRM problems.
3. Direct readout in relative dBs.

Disadvantages

1. Can still pick up TV video buzz and sometimes radar signals.

HP415E Notes. The HP 415E is a tightly tuned 1000-Hz audio meter. If you pick up a used one, first spray all the contacts in the range switch with contact cleaner.

The 415E uses a 700-ma 28-VDC NiCad battery pack. This is overkill, since the 415E pulls less than 10 ma. In the normal range it will work down to 8 VDC. In the expanded dB ranges it needs 16–18 VDC. I just mount a pair of 9-volt dollar-store batteries in mine and then it runs all day! On special occasions I'll put in three alkaline 9-volt batteries, as they seem to last a year or so with my typical operation.

On the back of the 415E is a BNC "Recorder" jack. This was used to drive an external stripchart recorder. The 1000-Hz signal is also on that jack in the same expanded range as the meter. Therefore, signals really jump out at you. Just make a BNC-to-audio adapter for some amplified computer speakers and you can listen to the signal. It's great for peaking the antenna without having to look at the meter. You also can instantly hear any video buzz or other interference on your 1000-Hz test signal.

Yes, it's called an SWR meter, but it was used with a slotted line to measure SWR. It is really just an AC volt meter tuned to 1000 Hz and calibrated in dB on the top and bottom scales. On the expanded scale you can resolve down to a 1/20th of a dB.

Network Analyzer. The "big boys" usually use a network analyzer to make these measurements. It's fancy equipment but very difficult to use in an open field, so it's not really suited to ham-type applications.

Advantages

1. Works over a broad range of frequencies.
2. Direct readout in dBs using the markers, and can output plots.

Disadvantages

1. Not a common piece of ham test equipment.
2. Works great in an EMI (electromagnetic interference) chamber, but is difficult to use outdoors.
3. Hard to see the display and peak an antenna when it is in direct sunlight.
4. Can easily be overloaded by local strong signals.

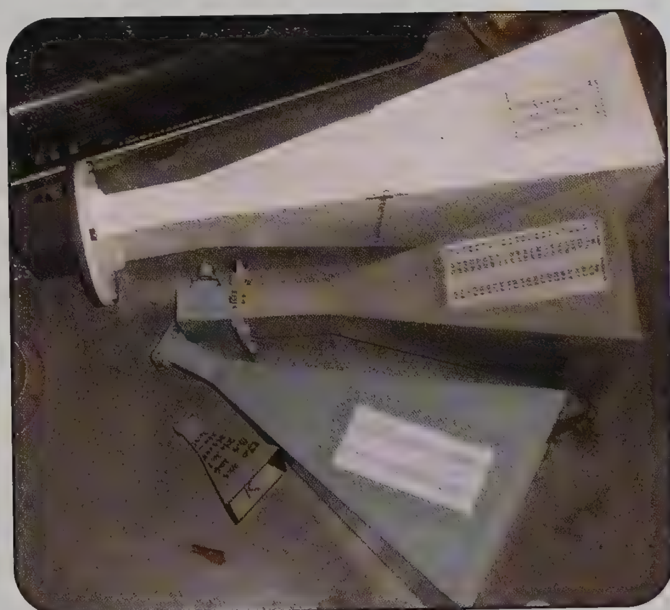

Photo D. Horn antennas are simple, hard to damage, and broadband, and their gain can be calculated with good accuracy. Thus, they make good reference antennas.

Letters, We Get Letters

Doug Wilson, WAØVSL, sent along this photo of his new AMSAT antenna. Doug combined the *CQ VHF* magazine articles about the three-element 145-MHz "cheap Yagi" and the six-element 435-MHz version to build this portable antenna. Thus far he has worked AO-27 and SO-50 with this antenna and a HT.

The new AMSAT antenna of Doug, WAØVSL.

5. Usually doesn't come with 250-foot cables so you can use them on VHF ranges.

Test Volume

You should find a test volume where the signal is constant to less than 1 dB of variation. Test-volume flatness is probably the greatest source of measurement error. If the signal varies by 2 dB over a 4-foot change in elevation or side to side and you are measuring a 4-foot dish, then one edge of the dish is seeing 2 dB more signal than the other edge. While the test equipment might be accurate to 0.1 dB, the measurement is off far more than that. However, with a little tweaking in the test-range geometry we can usually find an area with good signal-level flatness.

Test-volume flatness can be a real problem when comparing one Yagi to an array consisting of four Yagis. The signal is rarely flat on that large an area.

Test Distance

While the above holds true for Yagi arrays as well, it is much easier to visualize with a dish antenna. A dish antenna is focused much like a telescope or a camera. If you test it on a short range, the antenna is out of focus. If you tweak the focus on a short range, the antenna is now "near sighted." I once played on 10 GHz with a 12-foot dish on a 300-foot range. Oh, did I have the signal peaked! Looking for sidelobes, I moved the source around a bit. That's when I learned the beam was over a foot wide at 300 feet. The dish was focused—to a point. It had fantastic gain, but when pointed at the moon the pattern was then too broad. Luckily, not too many hams bring really big antennas to our CS VHF Society antenna contests, but we really have to back up when someone does.

There is a formula for far field:

$$R = 2\,(D^2)/\text{Wavelength}$$

where:
R = range
D = largest dimension of the aperture

In this case, a 1-meter dish on the 3-cm band (3 footer on 10 GHz for the rest of us) comes out to 67 meters, or about 200 feet. However, that formula is very pessimistic, and we find we can use about half that distance on our ranges with little error.

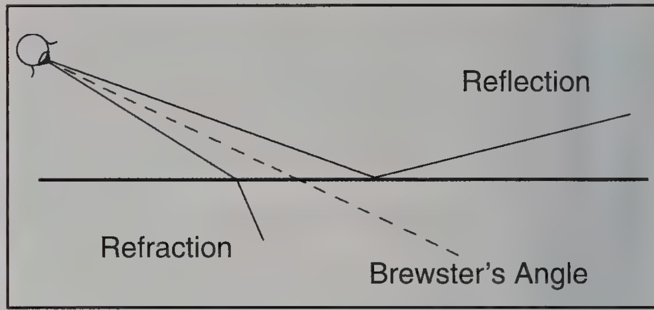

Figure 1. Brewster's Angle.

Reference Antennas

I like to use a horn antenna as my reference antenna whenever practical. They are simple, hard to damage, and broadband, and their gain can be calculated with good accuracy.

For some time now it has been a tradition to measure microwave radar antennas in dBi. The use of dBi simplifies many microwave antenna calculations for beamwidth and gain, so most 902 MHz and up measurements are in dBi.

For the CS VHFS range WBØTEM uses a family of reference Yagis for 50, 144, 222, and 432 MHz. Their gain is taken from a composite of over 25 years of measurements and hours of comparisons to a dipole. On my VHF/UHF range I use a reference log periodic that covers 140 to 1400 MHz.

Going back to the test-volume problems, ideally you like the gain of the reference antenna to be kind of close to the gain of the antenna being tested. Similar "capture areas" help measurement consistency and cut down on linearity problems in test equipment. Using antennas with 10 or 20 dB of difference can introduce errors when the dB range of the equipment is switched.

Brewster's Angle

Brewster's Angle is something we see all the time, but rarely think about it. Imagine you're standing along the shore of a clear mountain lake. The air is perfectly still and there's not a

Photo E. the author's favorite setup is a wide-band antenna and a wide-band signal generator.

ripple on the water. Across the lake you see the trees perfectly mirrored, reflecting off the water. You look down and see the minnows swimming around. *Wait!* Is the water a perfect mirror, or is the water transparent?

About 20 feet out you see a gray area where the water changes from transparent to reflecting. That angle is Brewster's Angle. You can also see this mirror effect on a sheet of plate glass at a shallow angle, and even on a highly polished piece of furniture.

We can use this effect on an antenna range. After all, you wouldn't make a parabolic dish out of asphalt or dirt. Dirt just doesn't reflect well. Yet we use ground bounce to get an extra 3 dB of gain out of many antennas. It's all a matter of angles. At shallow angles the ground looks like a mirror. At steep angles the ground looks like, well, just dirt. As the radio waves get shorter, it gets easier to take advance of Brewster's Angle. We can use a shallow take-off angle and set up a ground-bounce range, or we can elevate the antennas and let the dirt absorb most of the reflections.

Signal to Noise plus Noise

I like to have a 20-dB signal-to-noise ratio on the test ranges. There are several errors when you get close to the noise floor. As an example, if the reference antenna has a 1-dB signal over the noise and the test antenna is 2 dB, the extra gain in the test antenna is 3 dB, not 1 dB. Measurement errors such as this are a problem when the signals are barely above the noise. However, 20 dB extra signal can be a challenge on 24 GHz, 47 GHz, etc., so we often have to use plus 10 dB or so. That's another reason why we don't always like to make the range as long as the far-field equation recommends, but we can still keep the total errors to a few tenths of a dB.

My Favorite Setup

A wide-band antenna with a wide-band signal generator is the easiest setup. The ridge horn works from 1 to 18 GHz. It sure makes changing bands easy when you just have to punch in 2304.1 MHz and then 10368.1 MHz and not even switch antennas. Many of the newest signal generators no longer have a 1000-Hz AM position, but they all seem to have external AM modulation input. Thus, I just hook up a function generator and feed it the 1000-Hz modulation. Sometimes they like square waves and sometimes they like sine waves. I just use whatever gives me the maximum signal level on the HP 415.

Keep those letters and e-mails coming, gang. You are a great source of information and topics for columns.

73, Kent, WA5VJB

I believe that there is a lack of monitoring of the 2-meter band in general in the weak-signal area around the calling frequency of 144.200 during periods outside of VHF contests. This could be improved by awareness of weather conditions that lead to enhanced conditions. General indications of weather patterns that can lead to potential openings are provided by the Hepburn charts at <http:// home.cogeco.ca/~dxinfo/tropo.html>.

Like 6 meters, 2 meters experiences some propagation conditions that may be misunderstood by amateurs in general. In 2004 CQ published the book *VHF Propagation: A Practical Guide for Radio Amateurs,* written by Gordon West, WB6NOA, and myself (figure 3). This book covers all of the major propagation modes that are seen on the VHF bands, with special emphasis on 6 and 2 meters. An entire chapter of the book is dedicated to tropo, as it is a major mode of propagation on the 2-meter band. An audio CD with samples of different modes of propagation heard on 2 and 6 meters was made to accompany the book.

Two-meter weak-signal activity needs more day-to-day action. If it were not for the contests, and the times when there are some major propagation events, the lower portion of the band would be quiet much of the time.

Here is the simple two-element, 6-meter Yagi setup that Jon Jones, NØJK, used on one of his earliest trips to Bermuda a few years ago. Since then Jon has made several additional trips to Bermuda and has provided hams from both the U.S. and Europe with a chance to work Bermuda on 6 meters. (Photo by NØJK)

125 cm

Without a doubt, 125 cm, or 222 MHz, is the most under utilized amateur radio band of all, particularly in the area of weak-signal CW and SSB. A fair amount of progress has been made in the area of FM, with a decent variety of radios available over the past decade. However, in the area of weak-signal work there is a significant lack of commercially made CW and SSB gear for the band.

Just like 2 meters, 222 MHz is a good band for tropo enhancement and even for ionospheric skip modes such as sporadic-*E* and aurora backscatter on rare occasions. In fact, with the terrific aurora opening that occurred during the June 2005 VHF contest, a number of stations were able to make several 222-MHz aurora contacts in addition to contacts on the other VHF bands.

Indeed, 222 MHz does seem to generate a small amount of increased activity during the VHF contests held by the ARRL. However, most of the activity is on FM and only in certain areas of the country. When the ARRL publishes the scores for its three annual VHF contests, it shows the band breakdown. On many occasions, even during the September contest, it can be seen that there is a dearth of participation on 222 MHz in many of the major ARRL sections in the northeast and other areas as well.

It would appear that the lack of simple gear for 222-MHz CW and SSB operation has crippled the growth of this band. There was one commercially made single-band weak-signal radio that was made back in the 1980s by ICOM, the IC-375A. This particular radio is very hard to find today, and on e-Bay it can go for several hundred dollars. Transverter kits for 222 MHz are made by Down East Microwave. They are suitable for base-station operation, but perhaps are not quite as easy to set up for mobile or portable operations due to the need for extra wires and modules.

Presently, the only real way many VHF enthusiasts can get on 222 MHz is via the FM mode, either with mobile rigs or HTs such as this Kenwood TH-F6. Until reasonably priced commercial SSB and CW radios become available for 222 MHz, FM will be the dominant mode for this band. (Photo by WB2AMU)

At one point a few years ago I contacted a U.S. ham radio manufacturer with regard to a low-power 222-MHz weak-signal radio. This would have been a very interesting product, but unfortunately the manufacturer ceased operations. Don't expect the Japanese manufacturers to make this type of radio for U.S. hams, as there is no allocation for this band

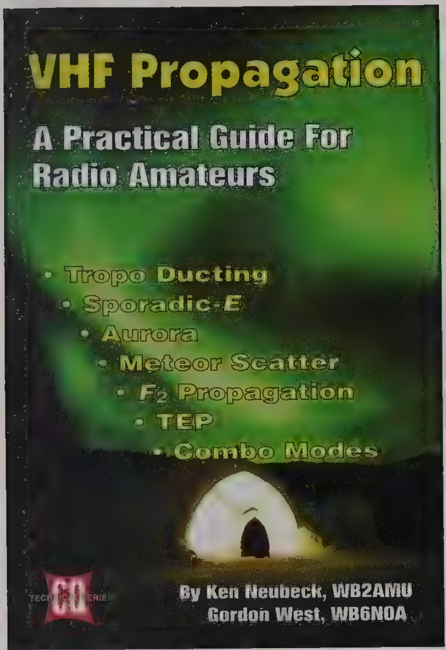

Figure 3. The 2004 VHF propagation book published by CQ and written by Gordon West, WB6NOA, and myself. It provides easy-to-understand details on the different propagation modes that are experienced on the VHF bands. A companion CD is available that has samples of the different VHF propagation modes. Note that the cover photo, taken by Chip Margelli, K7JA, is of an intense aurora, which is a major VHF propagation mode.

in Japan and they do not see a profitable market for a 222-MHz weak-signal radio in the U.S. and Canada.

Thus, no growth can be expected for the 222-MHz band in the weak-signal area, as there is no new gear readily available for SSB and CW. Any growth over the next few years primarily will be in the FM mode.

Two Challenges for the Future

There are many opportunities for the VHF community to promote growth. While the VHF contests are helpful in promoting activity at certain times of the year, there actually has been a leveling off or slight decline in overall participation in these contests. Some rules changes are probably in order to try to stimulate increased participation. Also, everyday activity needs to be increased, and I would like to issue the following two challenges to help improve the growth of VHF activity.

A number of *CQ VHF* readers have mentioned the need for more technical in-depth articles as well as increased focus on the weak-signal modes in this magazine. I would like to redirect the barrel of the gun in the other direction: what information do these readers have that they can share with the rest of the VHF community? It is one thing to send an e-mail or gripe on a chat page about perceived lack of technical or scientific material in a magazine, but there is an opportunity to step up to the plate and deliver some meaningful material! I therefore am issuing two challenges to the VHF community at large:

Challenge 1. Send in articles for *CQ VHF*! Some readers may have exceptional antenna setups on the VHF bands and thus see some consistent paths on 6 and 2 meters. These readers would do well to share this information with the VHF community to reveal some of the amazing capabilities of these bands. Anyone who has interesting propagation information or good technical projects should approach *CQ VHF* about a potential article, too. Don't worry if you need some editing help either, as the editorial staff and writers of the magazine will help you take your information and make it into an article suitable for publication.

Challenge 2. There have been requests from the readership for building-project articles. *CQ VHF* would be more than happy to present these projects. For many hams, available time is a major problem, as it takes coming up with a design, building it, troubleshooting, and then writing about the project. I remember building a 6-meter beacon from a Haywood/ DeMaw design and modifying it with different components. This took several weeks of construction and troubleshooting, resulting in an article in the first incarnation of *CQ VHF* some years ago. It was hard to find spare time on a daily basis to work on this project, and I imagine that many of others fall into the same category.

Thus, I would like to issue the following challenge: Someone out there build a QRP 222-MHz CW transmitter for under $250. If you can build such a transmitter with parts that can be readily purchased, and can make it on the order of 2 watts or more, we would be most interested in hearing from you. I am willing to help you develop a design and subsequent article; my contact information is on the first page of this article.

There are receivers in most of the HF plus VHF radios that cover the VHF bands, so a 222-MHz transmitter with a transmit/receive switch would be an ideal companion for these radios. This would go a long way toward increasing activity during the VHF contests and during certain band openings!

If you have ideas for technical articles and/or building projects and have been sitting on the sidelines, take this opportunity to take the plunge and contribute to the growth of VHF weak-signal activity by sending in your material! ■

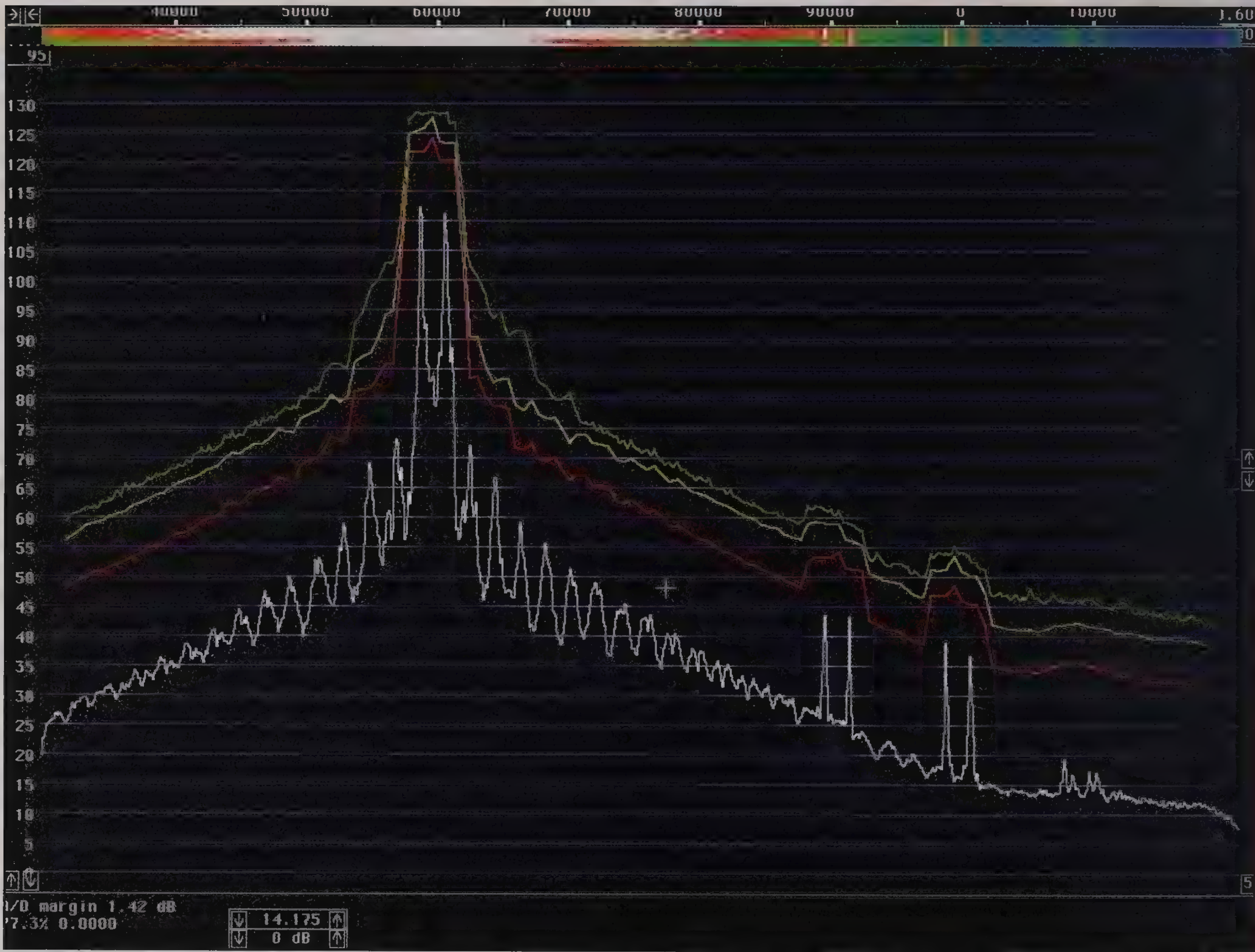

Figure 20. Worst-case spectrum on 14 MHz of an FT1000D in SSB mode, generated by the "Y/Ü" sound. Linrad in TX test mode.

wise the interference generated becomes a problem. Unfortunately, this is a problem in many transceivers. In fact, it is a problem in most of the transceivers I have looked at. For a detailed discussion, take a look at <http://www.sm5bsz.com/dynrange/alc.htm>.[12]

Using ALC to provide voice compression on SSB is a bad habit from old times. It was not a good idea back then, and it is really stupid in modern equipment. The ALC causes a lot of terrible splatter for no good reason at all. I have been told that amateurs want to watch the ALC meter to be sure the rig operates at full power. It would be much better to remove the control function and instead detect the drive level and show that on the meter. Driving the power amplifier slightly into saturation is not quite as bad as adding wideband modulation through the ALC. There could be some safety circuitry to protect the amplifier if necessary; this could work like the current ALC systems do, but it should be set for a somewhat

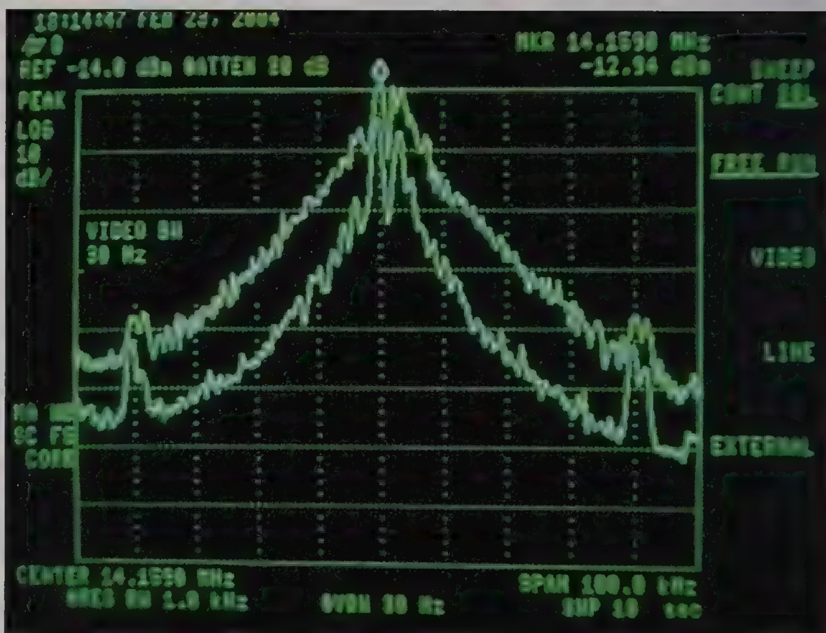

Figure 21. Signal similar to figure 20, but here as it looks on the HP8591A. A notch filter is used to remove the main signal, and the upper scale line is 35 dB below the peak level of the SSB signal.

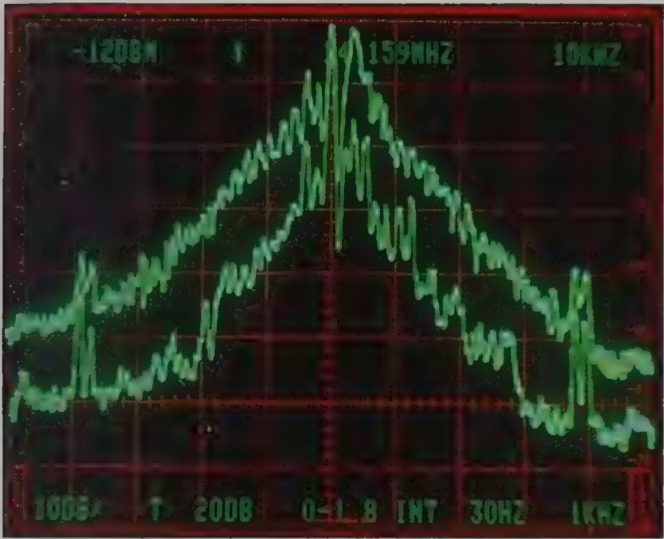

Figure 22. Signal similar to figure 20, but here as it looks on the TEK2753P. A notch filter is used to remove the main signal and the upper scale line is 35 dB below the peak level of the SSB signal.

higher level that should never be reached in normal operation. Modern transceivers with computer control could easily set the drive level right for each band and mode without adding wideband modulation . . . if amateurs wanted it like that.

The linearity of the power amplifiers typically is good enough. The results obtained in two-tone tests do not correlate at all with the splatter generated. The intermodulation products typically are far below the ALC sidebands with real-voice signals. In a two-tone test, the peak power is reached with a repetition rate of about 1 kHz, causing the saw-tooth waveform of the ALC to have a frequency of 1 kHz with very low amplitude. Therefore the two-tone test essentially shows the power amplifier linearity. However, testing with a real voice into the microphone shows what signals other band users really will have to cope with—and that is often something quite different and much worse.

I have used the IC706MKIIG as an example of how the spectra in Linrad test screen relate to the time-domain waveforms. Changing from Morse code to SSB does not make any fundamental difference, except that it becomes much harder to look at the time-domain waveform. The IC706 produces splatter on 14 MHz that seems to have the same origin in the

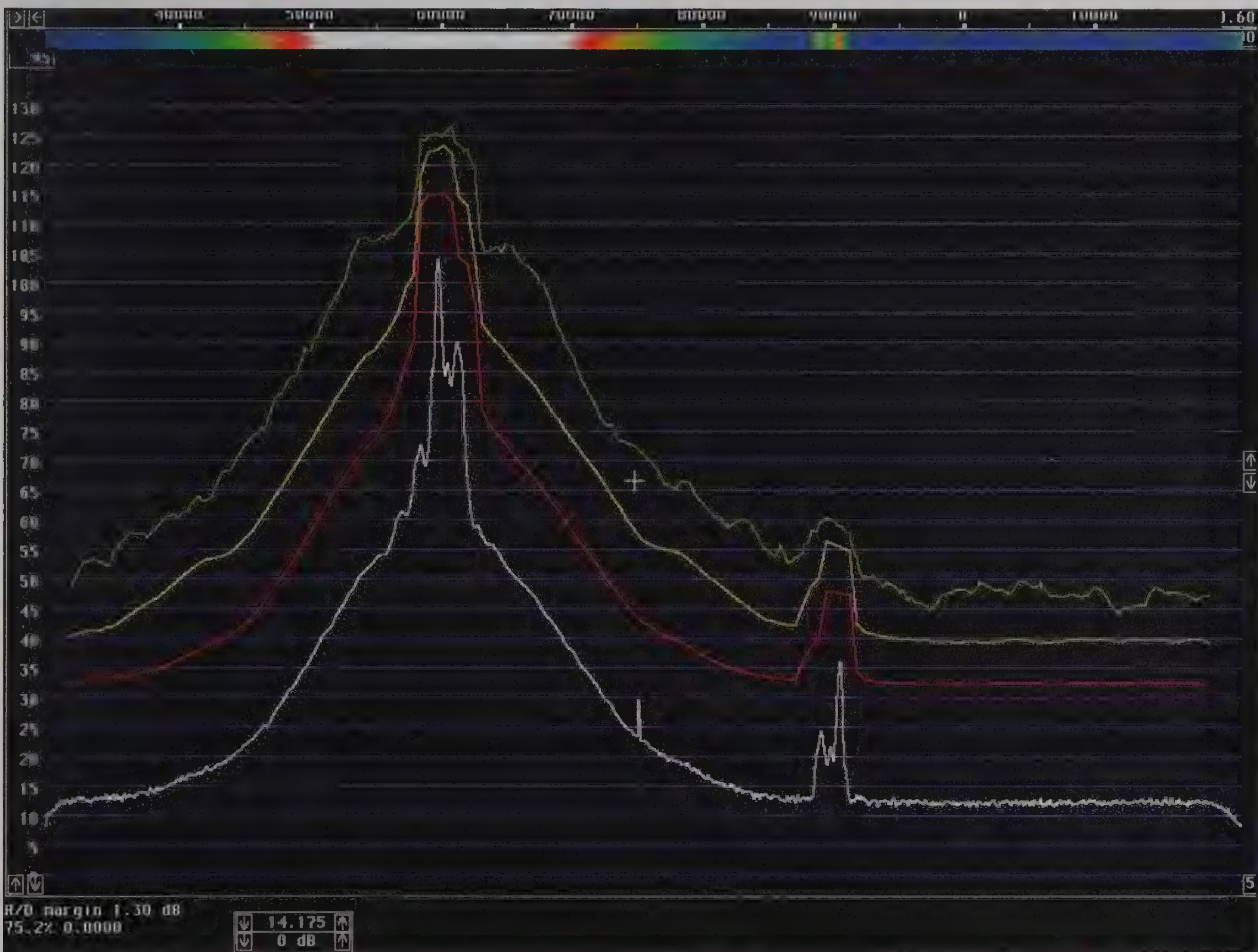

Figure 23. Worst-case 14-MHz spectrum of an IC706MKIIG in SSB mode.

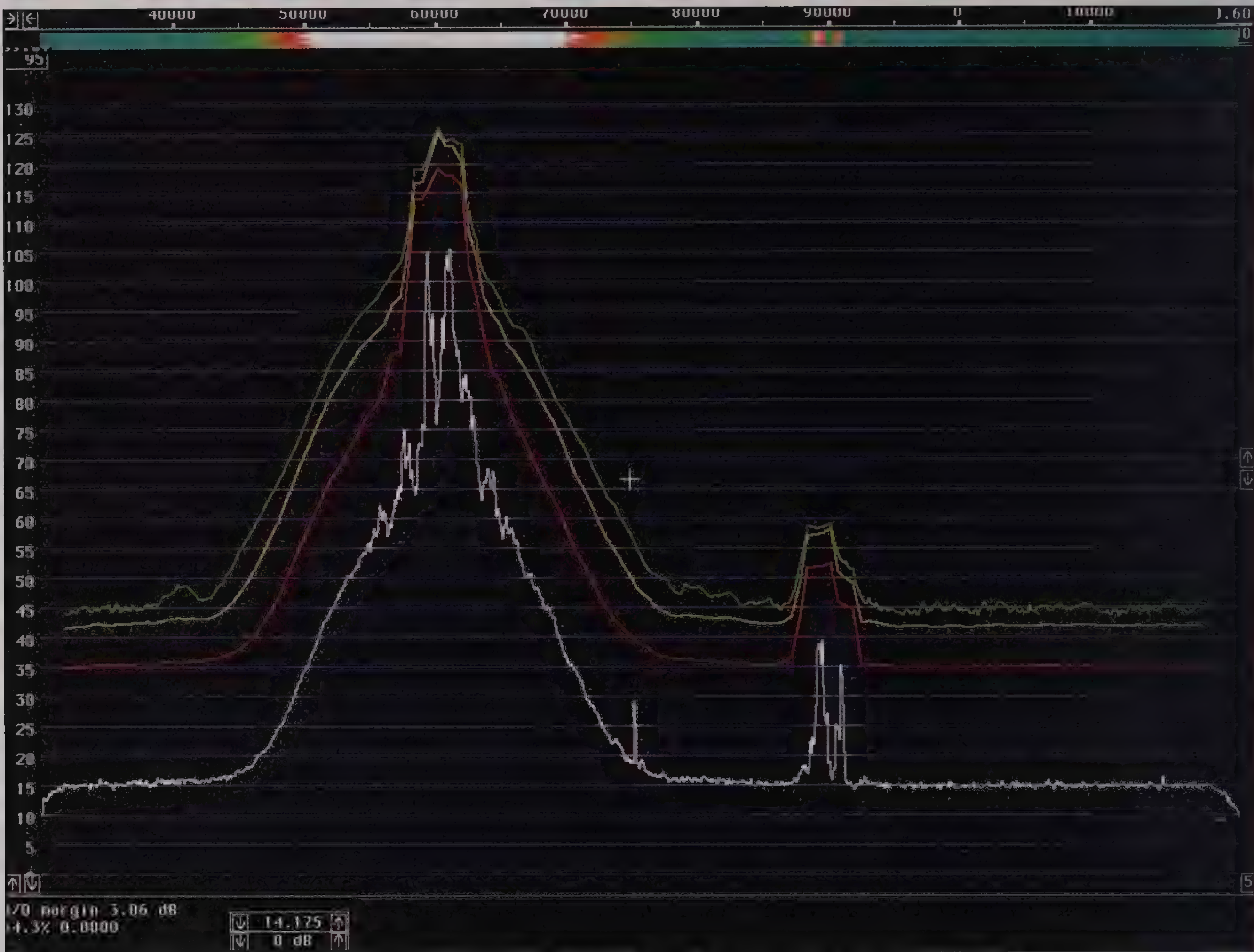

Figure 24. 14-MHz spectrum of an IC706MKIIG in SSB mode with the "Y/Ü" sound into the microphone.

ALC loop as the keying clicks (see later discussion about figure 23). Another example is the FT817, which is shown in figure 16. This particular unit must be regarded as faulty. I would not be surprised if the error is incorrect adjustment in the ALC circuit, but I did not have the time to look closely.

I do not think it would be difficult at all to eliminate the problems with the IC706MKIIG and the specific FT817 illustrated above. It probably amounts to reducing the gain a little to make the ALC less active. That is in theory. In real life it may be hard to do anything with miniaturized boxes such as these transceivers. I have never looked inside, so I do not know.

The peak-power spectra in SSB bandwidth show the quality of transmitters in a way that is honest for the customer who tries to find out which transceiver to buy.

The measurement is extremely easy with an FFT-based analyzer such as Linrad and the WSE converters as explained above. Just connect the transmitter to the WSE converter input through an attenuator and operate as normal. Linrad will catch the spectrum.

As for the average power spectra, it, of course, is also possible to use a standard spectrum analyzer such as the 2753P or 8591A together with a notch filter.

Measurements Using Notch Filters

The standard instruments from Hewlett Packard and Tektronix, the HP8591A and the TEK2753P, have different filter shapes as discussed above. Hewlett Packard uses Gaussian filters, which give faster response, while Tektronix uses more rectangular filters which allow better visibility for sideband noise. Figures 17 and 18 show what the screens look like at a resolution of 1 kHz when these instruments are fed with the signal from a low-noise crystal oscillator. The Linrad screen in "TX test mode" with a bandwidth of 2.4 kHz is shown in figure 19.

The crystal oscillator used for figures 17 to 19 has a sideband noise of about –169 dBc/Hz, so these figures directly give the limitations of the instruments. Amateur transceivers produce sideband noise at about –125 dBc/Hz when emitting an unmodulated carrier. It is obvious that neither the 8591A nor the 2753P can be used to check their performance directly. However, many transceivers emit splatter that is easily seen on the screen of these standard instruments. That is not because the instruments are especially good. It is because so many amateur transmitters are so bad.

Comparisons Among Transceivers on SSB

The FT1000D allows proper operation in SSB mode. When operating according

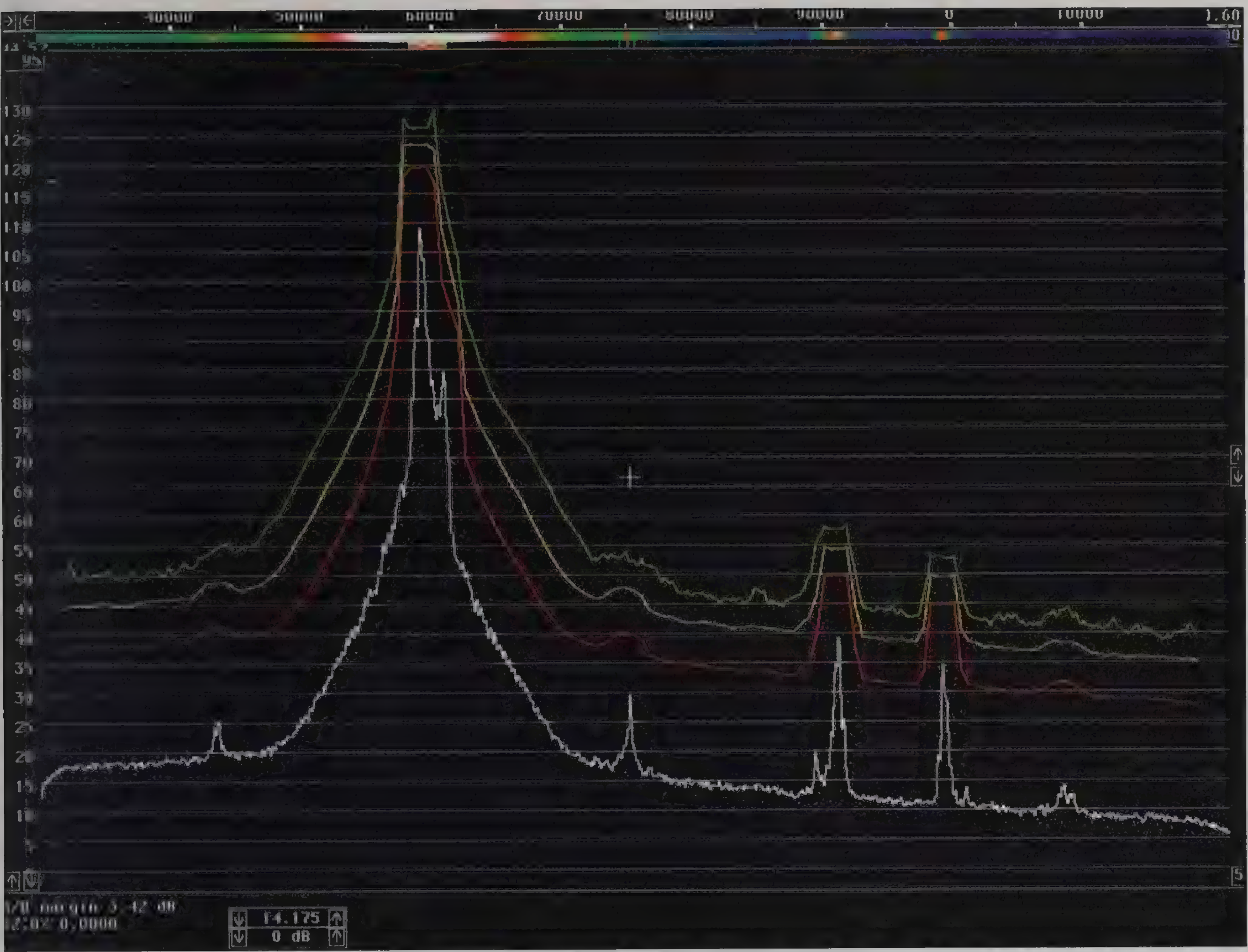

Figure 25. 14-MHz spectrum of an FT1000D with the "A-A-A-A" sequence into the microphone.

to the manual, the speech processor is used to set compression to 10 dB and the ALC circuit adds another 3 to 5 dB of compression, with some wideband splatter as a consequence. However, one can set the drive level to a point just below where the ALC starts acting, and then the speech processor can be used to set the desired compression, about 15 dB. For details, see <http://www.sm5bsz.com/ dynrange/alc.htm>[12], where you can find SSB spectra of the FT1000 that are representative of normal usage. Unfortunately, the transmitter amplifier is noisy, when the gain is not turned down by the action of the ALC. The sideband noise produced by inadequate noise figure in the transmit amplifier is at –116 dBc/Hz for a steady carrier at a frequency separation of 20 kHz. When operating according to the manual, the sideband noise is at –120 dBc/Hz because of the reduced gain due to the ALC. The obvious solution would be to make a modification that provides a constant voltage that gives a permanent gain reduction.

The FT1000D typically produces a very clean spectrum when one speaks into the microphone like one would do in a QSO, but there are occasional outbreaks of splatter. Such splatter peaks seldom occur; it happens when I say a sound right between "Y" (as in YES) and the German "Ü" (as in ÜBER) into the microphone. This particular sound happens to generate essentially two sine waves that are separated by nearly 2 kHz. As a consequence, the ALC does not generate any distortion to the waveform because the maximum power repeats at a rate of 2 kHz. This particular interference is generated by the cross-over distortion in the power amplifier and/or driver stages as will be shown below. The purpose of transmitter testing is to find the weak spots of each transmitter and to characterize them so that users can minimize the problems and manufacturers will be able to improve the equipment. The weakest spot (worst-case interference) of the FT1000D is that rare "Y/Ü" sound, which is a selective phenomenon and not a big problem in actual usage. For representative spectra in normal voice again see <http://www.sm5bsz.com/dynrange/ alc. htm>.[12] The worst-case interference of the FT1000D is shown in figure 20. Figures 21 and 22 show the same as seen with the standard instruments from HP and Tektronix with a notch filter that removes the desired SSB signal.

Figures 20 to 22 show the same thing. All three show the peak-hold spectra and the average-power spectra. In SSB mode the important information comes from the peak-hold spectra, because the average power spectra are difficult to obtain in SSB mode on a sweeping analyzer. It is not so easy to keep producing the worst splatter level by voice for the long duration of a

single sweep at a video bandwidth of 30 Hz, but the peak-hold measurement is straightforward and easy in SSB mode on all three instruments and the average power spectrum is inconsequential to produce for a continuous carrier.

At a frequency separation of 20 kHz, the peak splatter level is –60 dB relative to the peak power in the Linrad 2.4-kHz measurement. The 8591A gives –63 dB in a bandwidth of 1.14 kHz, while the 2753P gives –66 dB in a bandwidth of 722 Hz. The splatter is neither pulses nor white noise, so it is unclear how the peak amplitude relates to the bandwidth. The results indicate that the character of the splatter in this case is like white noise with a level of –60 dB in 2.4-kHz bandwidth.

The worst-case speech waveform is different among different transmitters. Figure 23 shows the worst-case emissions from an IC706MKIIG. This rig suffers from the ALC problems that were discussed above in conjunction with figures 8 to 11 as judged from the similarity of the spectra. This particular rig does not produce much interference with the "Y/Ü sound; instead, the worst-case interference is produced by the sequence "A-A-A-A-A," with the short "A" sound repeated at a rate of something like 5 Hz with less than 50% duty. The spectrum is displayed in figure 23. Note that the peak power in the neighbouring channels is not even 20 dB below the power of the main signal, most probably due to the ALC malfunctioning. The IC706MKIIG splatter drops rapidly with increasing frequency separation and it is obvious that the mechanism is different compared to figure 20.

Figure 24 shows the IC706MKIIG with the "Y/Ü" sound into the microphone. As expected, the splatter that is probably generated by the ALC is absent, the spectrum looks very clean and the cross-over distortion causing the problems in the FT1000D is obviously insignificant in the IC706MKIIG. Figure 25 shows the FT1000D with the "A-A-A-A" sequence into the microphone. The rig is operated according to the operating manual with full ALC. As shown in [12] the spectrum is even narrower without the ALC.

Figures 24 and 25 show very clearly that the waveform that one transceiver can not handle well is no problem at all for the other transceiver. It seems like almost every transmitter has its own peculiarities. Figure 26 shows the spectrum of a TS-520. For this rig there is not a single sound that could be found to make the worst interference, although the spectrum shape varies with the different sounds. Figure 26 shows the word "Echo" repeated rapidly. Saying several other words as well will lift

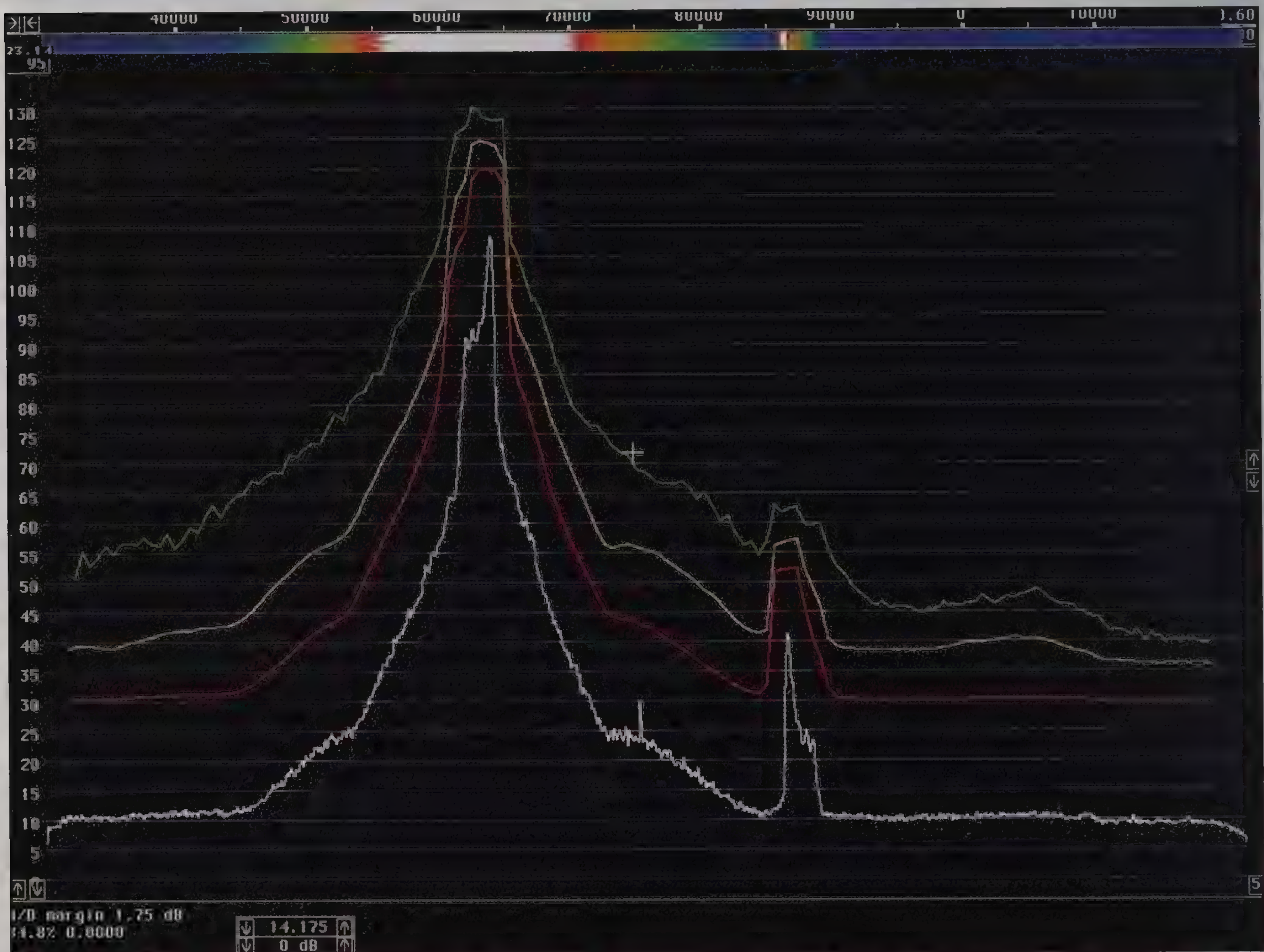

Figure 26. 14-MHz spectrum of a TS-520 with the word "Echo" repeated into the microphone. The unit is operated with ALC at about 25% of the ALC range.

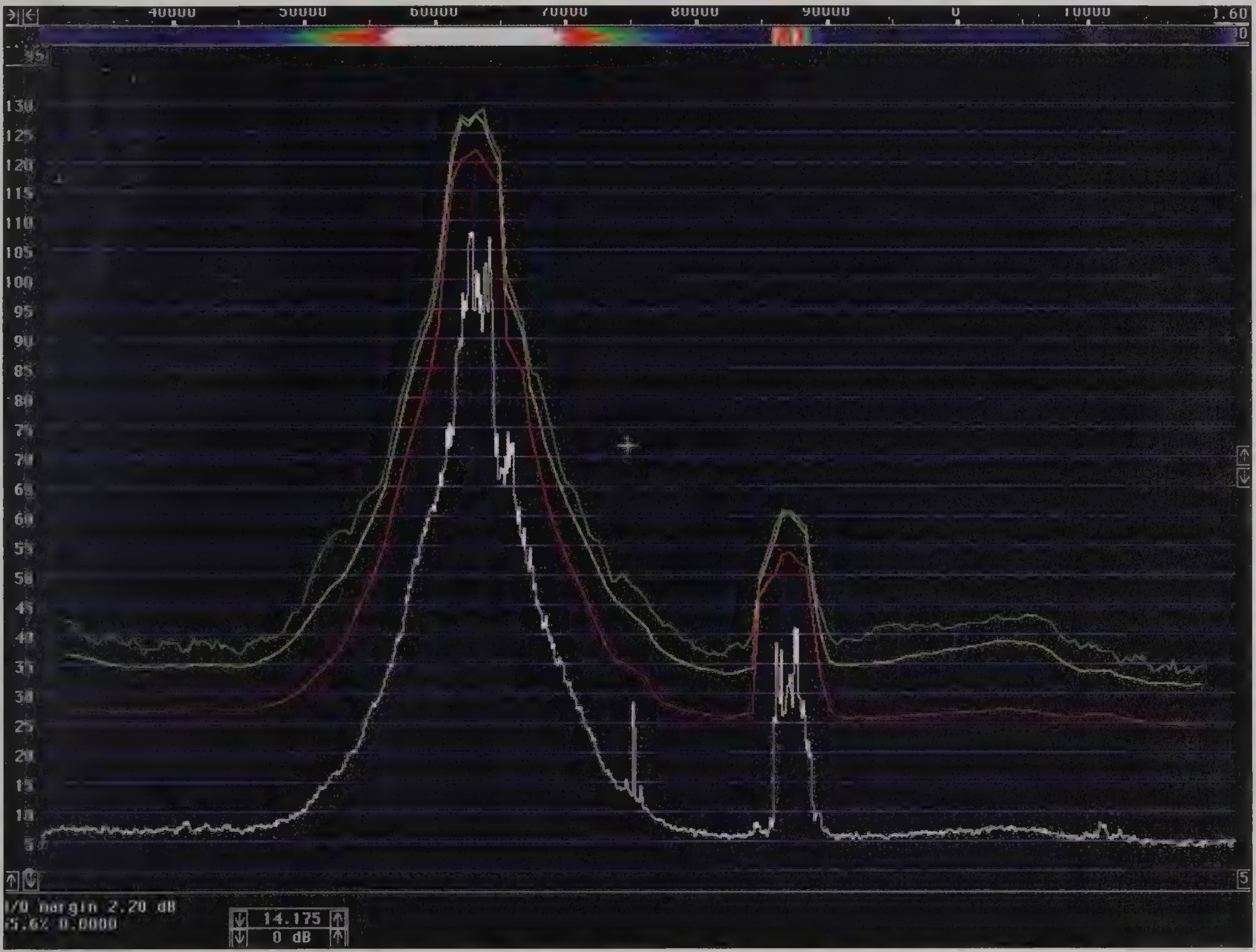

Figure 27. 14-MHz spectrum of a TS-520 with the "Y/Ü" sound into the microphone. The unit is operated without ALC but with full output power.

the peak hold spectrum a bit higher, but not very much. The interference in the TS-520 is caused by the ALC, which was peaking about 25% of the ALC range according to the meter. By slightly mistuning the PA drive so that the ALC meter does not move at all, and setting the mic gain higher to give the same average output power, the splatter generated by the ALC can be removed. Operated this way the TS-520 emits a very clean signal. The difficult test cases, the "Y/Ü" sound and the "A-A-A-A" sequence are shown in Figures 27 and 28. Saying the word "Echo" into the microphone does not cause more splatter than the "A-A-A-A" sequence when the ALC is disabled.

Conclusions and Discussion

Testing transmitters is a far more complicated task than testing receivers. It is complicated in the sense that it is very difficult to set up a standardized test that has a chance of being generally accepted and that would be relevant as a figure of merit for the spectral purity of a modulated transmitter.

From a practical point of view it is very simple, however. Just modulate the transmitter in every possible way that is in accordance with the instruction manual. Collect the peak-hold spectrum in an SSB bandwidth and present the graph with some notes on which kind of modulation the rig has difficulties with (if any). Not only spectra at full power should be investigated. Some rigs send out massive wideband pulses when the PTT is pressed or released, while others emit high levels of wideband noise during silent periods in SSB when the ALC does not reduce the transmitter gain. With a wideband FFT spectrum analyzer it is easy to find the peculiarities of a transmitter and measure the worst spectrum.

The measurement can also be made with standard instruments if a notch filter is added to extend the dynamic range. It just takes some more time, because with a sweeping analyzer a single transient will affect only one frequency at any given moment.

A modern transceiver should provide a peak-hold spectrum like the old TS-520 in figures 27 and 28, or better. However, this is very far from what the measurements actually show, because transmitter quality is not receiving its due share of attention. Once this problem does begin to receive some thoughtful attention, it will be very easy to make improvements. Aside from silly things such as emitting a very short pulse at full power when the PTT is pressed, most problems can be eliminated by reconfiguring the ALC and by making sure there is an amplitude clipper at the right side of the SSB filter—the input side.

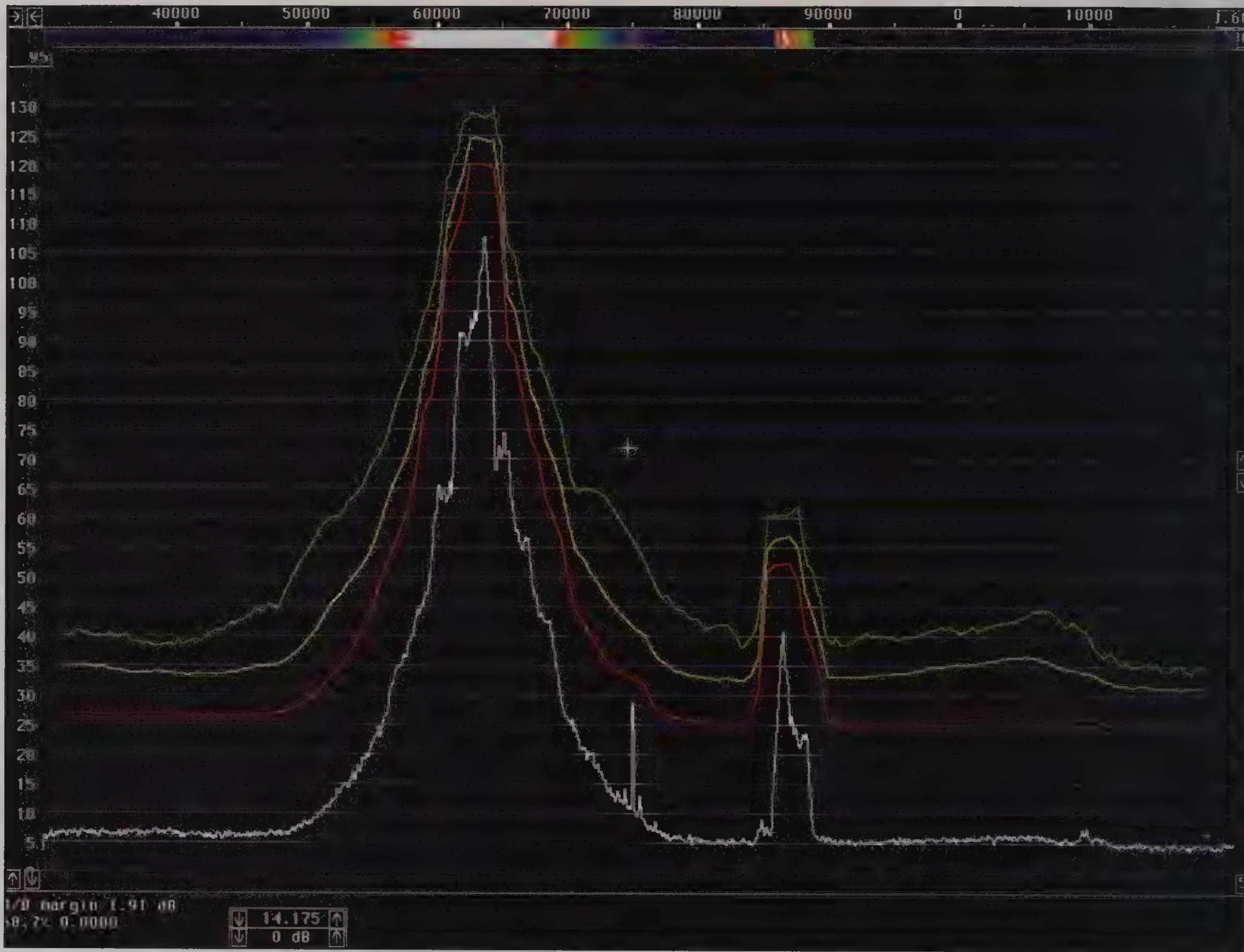

Figure 28. 14-MHz spectrum of a TS-520 with the "A-A-A-A" sequence into the microphone. The unit is operated without ALC but with full output power.

There is also a need for some care to avoid excessive noise figures in the first transmit amplifier after the SSB filter to prevent high levels of wideband noise (as in the FT1000D, for example [see figure 25]).

Two peak-hold spectra, one in CW mode and another in SSB mode, will provide all the relevant information about transmitter spectral purity that is needed for a product review.

The test engineer might want to show some more spectra, probably different for each transmitter, because there may be specific events, such as pressing the PTT button, that make the spectra absolutely horrible. It then makes sense to show the spectrum as it looks when such events have been excluded from the time-frame of the measurement. Likewise, it may be relevant to show spectra with VOX or QSK off in case they differ significantly from the spectra when they are enabled. Such differences are due to design inadequacies that would be easy to correct, so the place where these measurements should first be made is in the manufacturer's design laboratory!

There is an element of arbitrariness in the peak-power spectra. Finding the special sound to make the FT1000D emit the horrible spectrum of figures 20 to 22 was not so easy. The first test—saying "Aaaaa, testing, testing, one, two, three" a few times—did not show anything unusual. If I had been satisfied with that, the outcome would have been a result such as the one in figure 25. However, by trying various other phrases as well as speaking at several different voice pitches, it was not difficult to find a much worse peak-hold spectrum. Once I knew there was something to look for, it then was fairly easy to find the exact sound to produce worst-case interference.

The FT1000D used for this article has a normal two-tone test result, as one can see in figure 29. It is a delicate balance, however, and by making the two tones slightly different in amplitude one can get much worse high-order intermodulation. By increasing the separation between the tones one can also get a slightly worse result. Such a modified two-tone test is displayed in figure 30. Note that it is very similar to figure 20. The high-order intermodulation that the FT1000D suffers from does not change when the output power is reduced, unlike the low-order components. The high-order intermodulation is caused by insufficient bias current, and stays at the same level with respect to the peak power from about 20 watts to full power. However, at the same time the low-order intermodulation changes drastically.

At a power level of about 1 watt the FT1000D spectrum looks like figure 31. Note that the third-order intermodulation product is only about 22 dB below the peak power. This is a very sig-

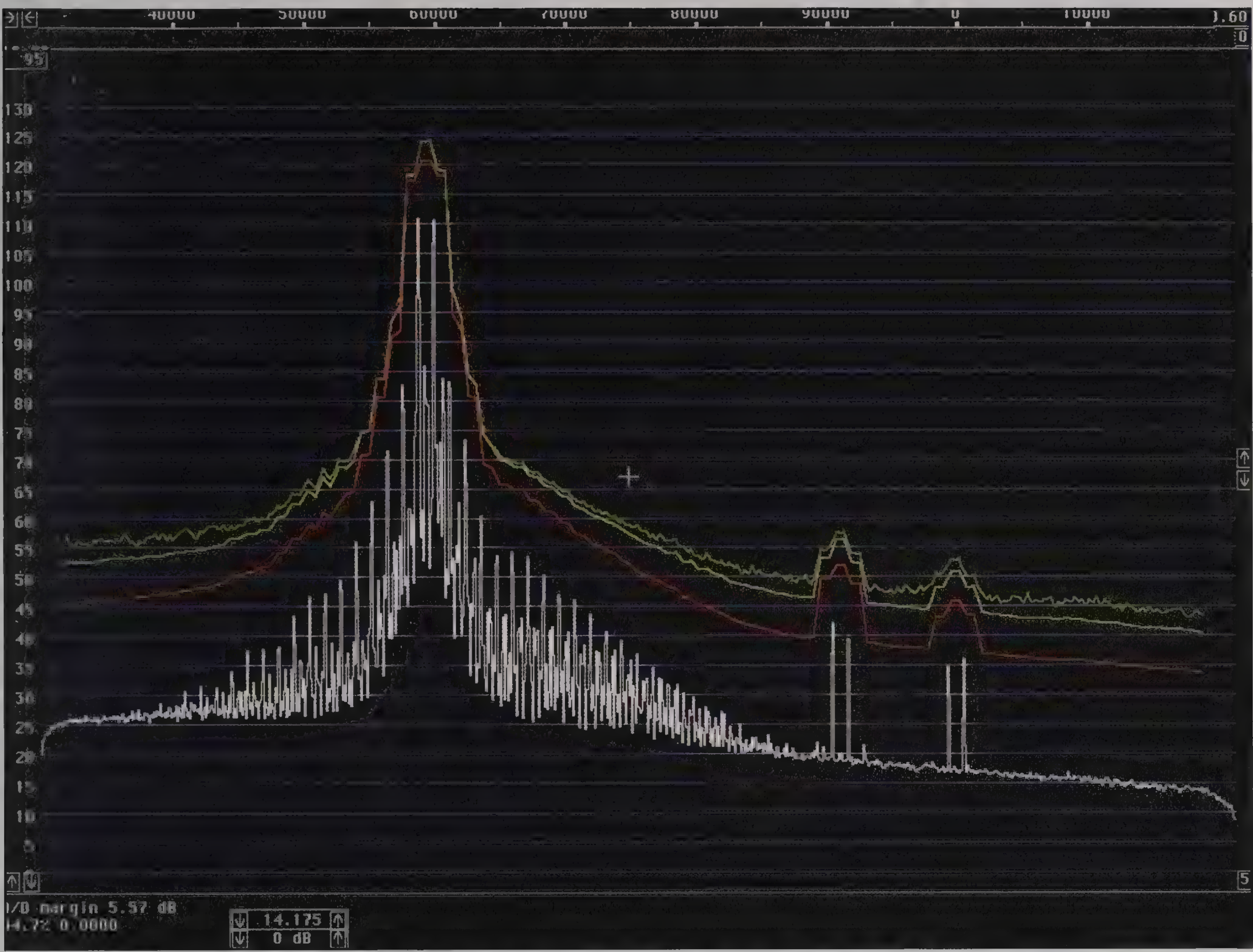

Figure 29. Standard two-tone test for the FT1000D. The tones are 700 and 1900 Hz.

nificant distortion of the signal, well visible in the time domain, as one can see on the oscilloscope trace in figure 32. At the zero crossings the envelope should have its steepest slopes, but as can be seen in figure 32, the slope is only about 50% of its correct value, which means that the amplifier gain is about 6 dB lower than it should be at output voltages about 20 dB below a power level of 1 watt. This kind of distortion is commonly referred to as cross-over distortion, since it is equivalent to cross-over distortion in hi-fi amplifiers, where the name is fully appropriate.

Personally, I think that excessive high-order intermodulation is a direct consequence of the standardized two-tone test, because of the unbalanced emphasis that it gives to the lower (third and fifth) orders. The relatively low level of the third-order intermodulation visible in the standardized two-tone test may well be a consequence of design engineers tweaking the bias current of the PA and perhaps the driver stages for optimum third- and

fifth-order performance without regard to any other consequences. The normal third-order intermodulation can be described as loss of gain at maximum power, as the envelope is flattened slightly at the maximum power. By deliberately setting too low a bias current to create a loss of gain at the zero crossings as well, one can add another third-order intermodulation component that is in antiphase and thus reduces the total third-order intermodulation. Such techniques are well known and often are used to take advantage of rigid type-acceptance test protocols, but the adverse consequences for wideband splatter are visible as increased levels of higher order intermodulation, even in the standard two-tone test. If the FT1000D had been designed to produce good results in the peak-hold spectrum, the bias current would have been just a little higher. The third-order intermodulation in the two-tone test would have been a little higher too, but the higher order components would have been much lower—and that is what matters most to other band users.

I have been told that the FT1000D is known to produce very clean SSB signals on the bands—"one of the best rigs." Knowing about the cross-over distortion, amplifier noise, and ALC modulation from which it suffers, and how easy it could have been to eliminate all these problems at the development stage, the conclusion is that the current state of the art in amateur radio transmitters is highly unsatisfactory. Bad design is not limited to careless keying.

Besides the test of the purity of modulated emissions, a product review should also include a measurement of the sideband noise of the unmodulated carrier, since it gives interesting information about the quality of the frequency-generating circuits. The levels of the noise sidebands are easily measured with good accuracy using standard instruments and a notch filter. It is not safe to assume that the reciprocal mixing test in RX mode tells us everything; the TX signal path is different, so a separate test is needed, and a comparison with the two-signal dynamic range of the receiver may give interesting information. In fact, it is quite common for transmitters to be much noisier than receivers, and most often this is due to silly design errors that could be easily rectified. The main requirement now is to escape from the fixation on receiver performance—that problem is now essentially solved[2]—and begin to give transmitter performance the share of attention that it deserves.

Notes

1. Leif Åsbrink, SM5BSZ, "Receiver Dynamic Range," *DUBUS* 4/2003, pp. 9–39, and *DUBUS* Book *TECHNIK VI,* pp. 348–378. Also see <http://www.sm5bsz.com/dynrange/rig_compare.htm> and links from there, plus the Fall 2004 and Winter 2005 issues of *CQ VHF.*

2. Peter E. Chadwick, G3RZP, "HF Receiver Dynamic Range: How Much Do We Need?" *QEX,* May/June 2002, pp. 36–41.

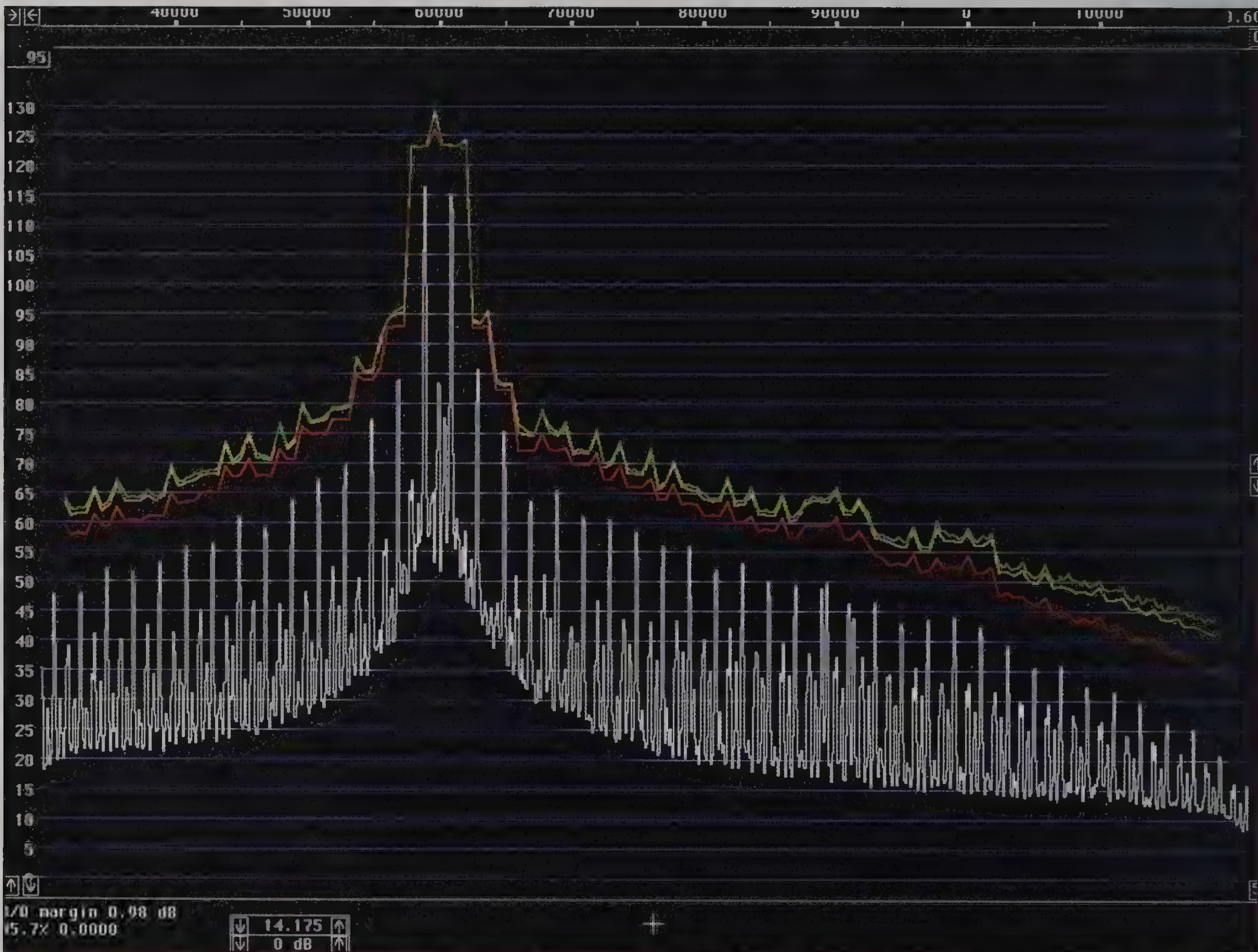

Figure 30. Slightly modified two-tone test for the FT1000D. The tones are 400 and 2400 Hz. The amplitude ratio is adjusted for worst high-order intermodulation.

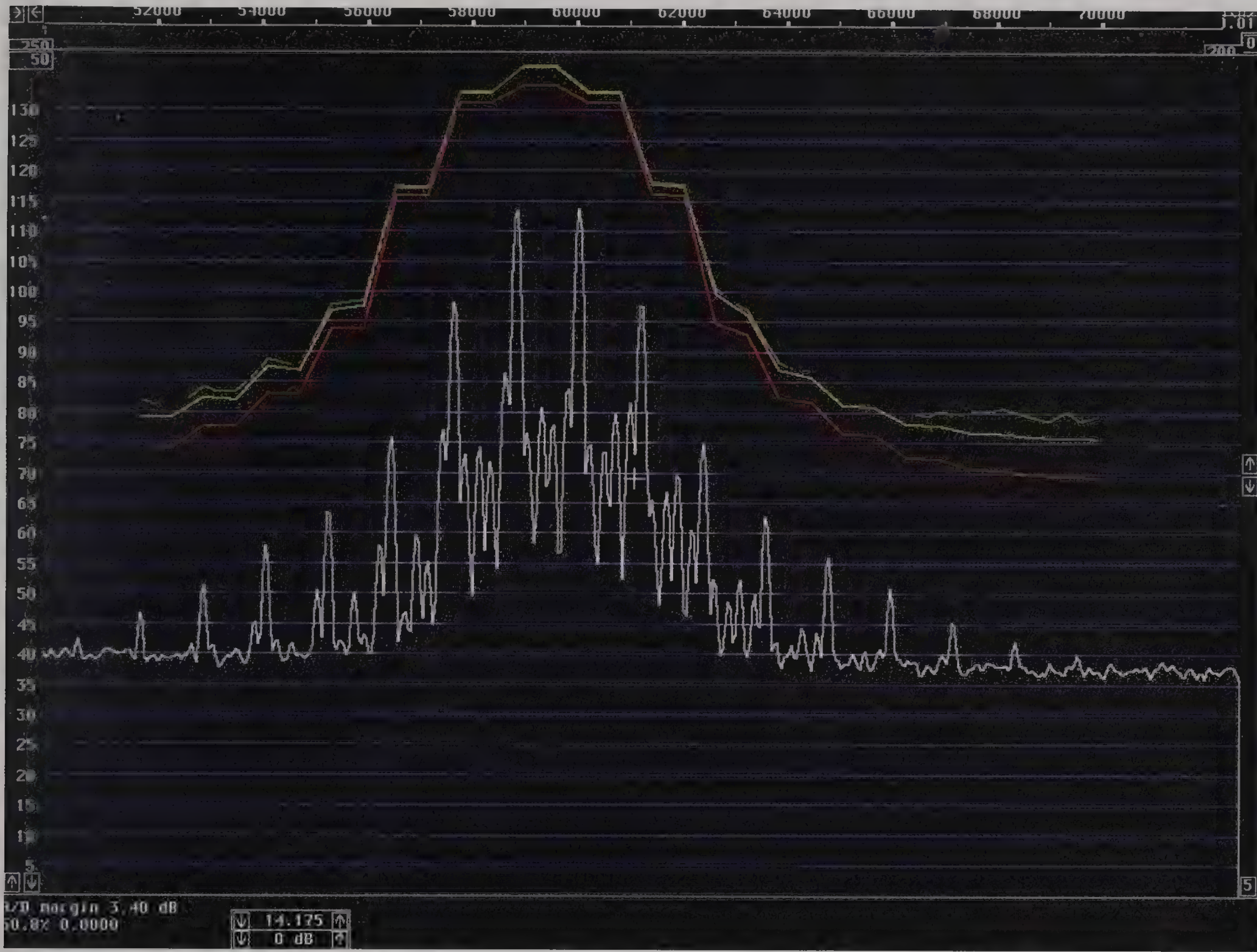

Figure 31. Two-tone test for the FT1000D at about 1 watt peak power. The tones are 700 and 1900 Hz.

3. <http://www.sm5bsz.com/linuxdsp/linrad.htm>

4. Mike Gruber, WA1SVF, "Improved Transmitted Composite-Noise Data Presentation," *QST*, February 1995. p. 59.

5. <http://www.sm5bsz.com/linuxdsp/optrx.htm>

6. Doug Smith, KF6DX, "On the Occupied Bandwidth of CW Emissions," <http://www.doug-smith.net/downloads.htm>. There is also a copy at the SM5BSZ home page: <http://www.sm5bsz.com/others/occbw.htm>.

7. *The ARRL Handbook,* 1994. Figure 11 is on p. 9-9.

8. Kevin Schmidt, W9CF, "Spectral Analysis of a CW Keying Pulse," <http://fermi.la.asu.edu/w9cf/>. There is also a copy of this article at the SM5BSZ home page: <http://www.sm5bsz.com/others/click.pdf>.

9. <http://www.w8ji.com/keyclicks.htm> and <http://www.w8ji.com/keyclick_mp.htm>

10. <http://www.qsl.net/n1eu/Yaesu/MPclicks.htm>

11. <http://www.qth.com/inrad/kits.htm>

12. <http://www.sm5bsz.com/dynrange/alc.htm> ■

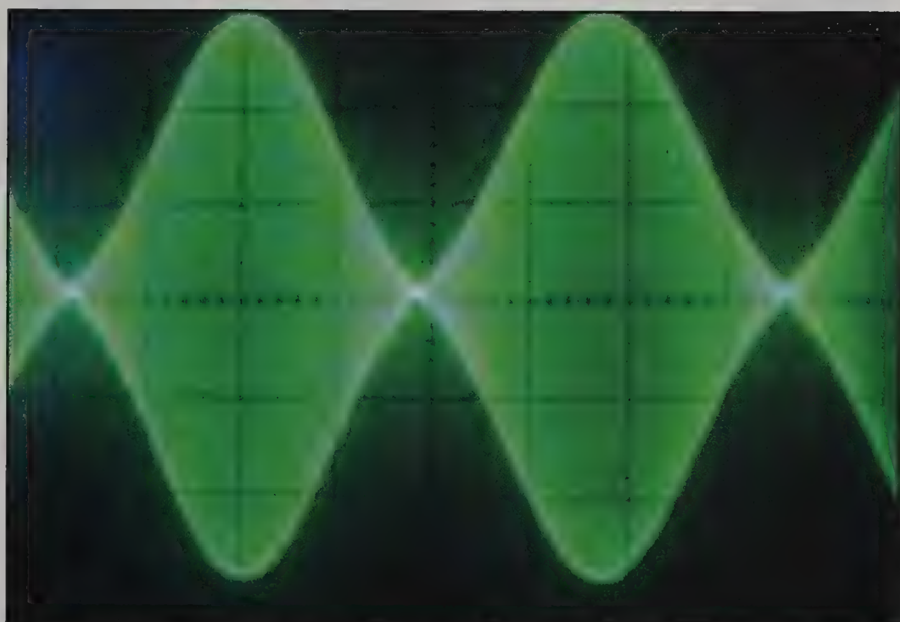

Figure 32. Two-tone test for the FT1000D at about 1 watt peak power. Same signal as in figure 31, oscilloscope trace of the 14-MHz RF signal.

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Remembering W8FIS, the Father of SETI

It grieves me to report the passing of a legend, and an honored friend. I have been informed by his son Bert that Professor Philip Morrison, co-author of the world's first serious scientific paper on SETI, passed away quietly at home on Friday, April 22, 2005. He was 89 years of age.

Dr. Philip Morrison, Institute Professor and Professor of Physics at the Massachusetts Institute of Technology, was a distinguished theoretical astrophysicist and a pioneer in the search for extraterrestrial intelligence through radio communication. He authored scores of books, produced television documentaries, and lectured tirelessly around the world, despite the physical limitations imposed upon him by post-polio syndrome. In one of his many roles as a science educator, Dr. Morrison served on the board of advisors for the television science series "NOVA." In another role, he was columnist and book reviewer for *Scientific American*. In yet a third, it was Phil Morrison who chaired NASA's early study groups on SETI.

Along with most of the bright young physicists of his generation, Phil Morrison spent the war years working on the Manhattan Project, the development of the first atomic bomb. Unlike many of his Los Alamos colleagues, he went on to become a staunch pacifist, anti-war activist, opponent of nuclear proliferation, and a co-founder of the Federation of Atomic Scientists (later known as the Federation of American Scientists). I asked him, just a few years ago, if he regretted his wartime activities.

"On the whole, no," was his paradoxical reply. "At the time, we believed Germany was close to developing an atomic bomb. Even when they failed to do so, ending the war with Japan remained a priority. The regrettable bombings of Hiroshima and Nagasaki did bring that conflict to an end, and saved countless tens of thousands of lives on both sides. My only regret is the dark period that followed."

*Executive Director, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

Undeniably one of the patriarchs of SETI, Professor Morrison had long since gone inactive on the ham bands when in 1959 he coauthored "Searching for Interstellar Communications" in the British science journal *Nature*. His boyhood interest in amateur radio had motivated his interest in exploring the feasibility of microwaves for interstellar communication. During SETI's Golden Age, he inspired a whole generation of engineers and scientists, including the founders of The SETI League, to think beyond human limitations.

On a personal note, my own SETI interests were motivated by following in Phil Morrison's footsteps (albeit from a distance of 30 years). As an electrical engineering undergraduate at the Carnegie Institute of Technology, I had the privilege of operating W3NKI, the campus ham radio station Phil had founded three decades prior. From Carnegie Tech, Phil went on to earn a Ph.D. from the University of California, Berkeley. Many years later, so did I. Phil encouraged my SETI League efforts from the start. He did me the great honor of writing the jacket blurb for my hypertext book *Tune In The Universe!* (copyright © 2001, ARRL), contributed generously to The SETI League of his time and financial resources, and over the years became a close friend and mentor.

Phil Morrison is remembered as much for his modesty as for his energy. Nearly a decade ago, on November 7th, my wife Muriel and I happened to be in Cambridge MA, where I was to interview that year's crop of outstanding MIT and Harvard graduate students. We rang up Phil's wife and longtime collaborator, the late Phylis Morrison, and asked if we could get together. She immediately suggested their favorite Japanese restaurant, where we met, dined, and talked until closing time, whereupon Phil insisted on picking up the check. From the restaurant, the four of us went to the Morrisons' modest Cambridge flat, where we proceeded to sit up half the night, engaging in one of the free-wheeling and intellectually stimulating conversations for which the Morrisons were noted.

Phil Morrison and the author's wife, Muriel Hykes, share their favorite technical journal, at a BioAstronomy Conference in Italy in 1996.

A week later, having returned home, I began working on an essay which was to include a mention of Phil and his contributions to the art and science of SETI. In order to get my facts straight, I thumbed through my well-worn copy of David Swift's *SETI Pioneers* to Phil's biography and was shocked to read his date of birth—November 7, 1915. We had spent the whole evening of his 80th birthday together, and neither Phil nor Phylis had said a word about it!

I rang up Phil, and asked, "Why didn't you tell me it was your birthday?" He replied, "Because if you had known, you might not have come."

My last telephone conversation with Phil Morrison occurred seven weeks ago, as I write this, following the death of my own father (they were of the same generation). I expressed concern for Phil's health, and we made plans to celebrate his 90th birthday, next November 7th. A father figure to many of us, Phil Morrison's death leaves a void that can never be filled—but I feel compelled to try. When I grow up, I want to be just like Phil Morrison. 73, Paul, N6TX

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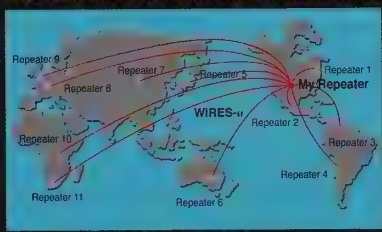

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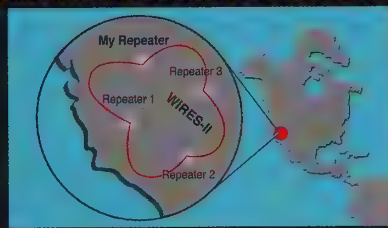

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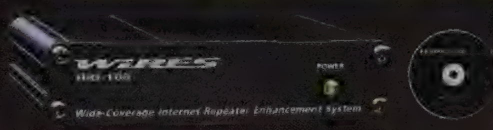

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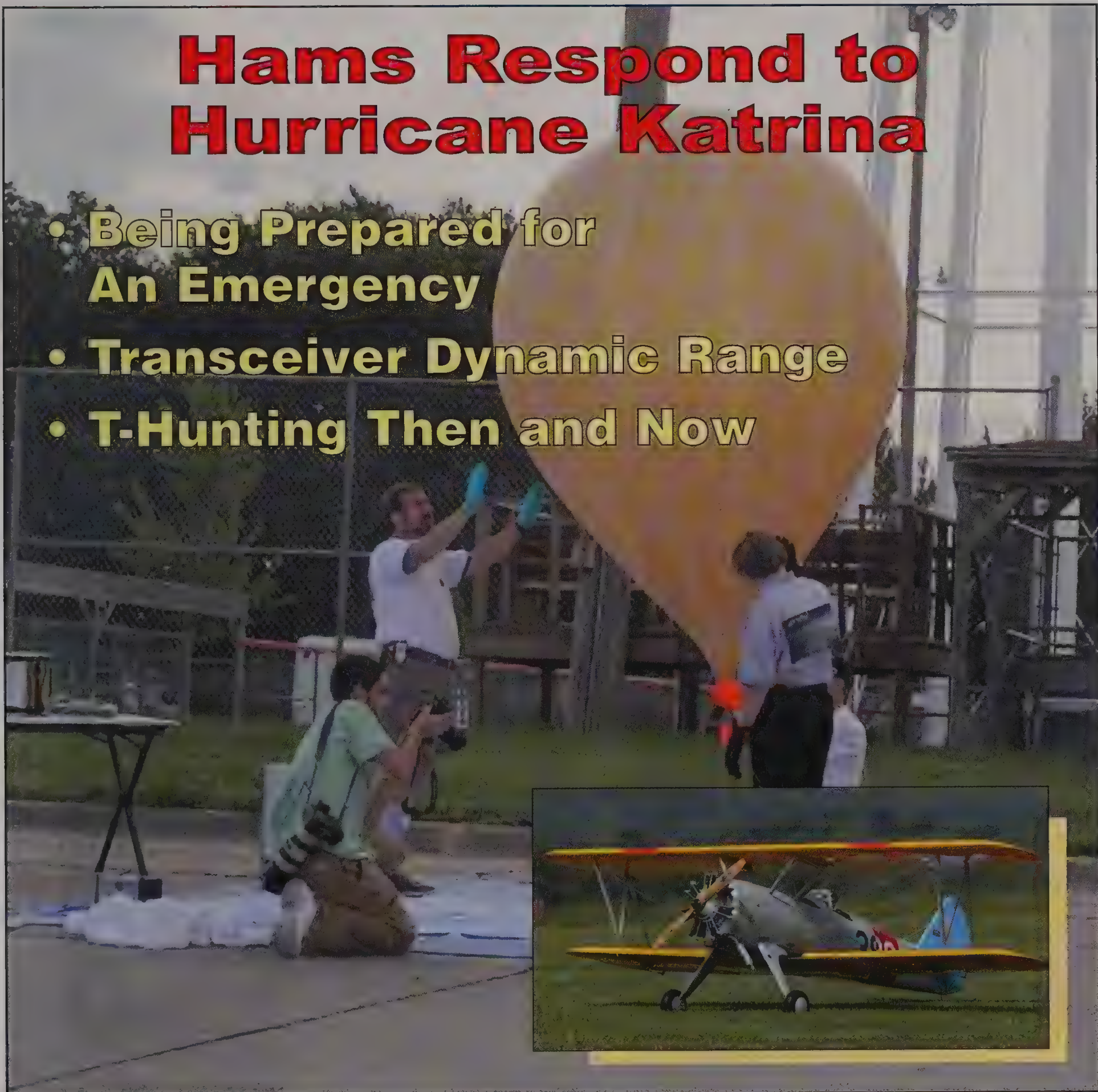

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Periodical postage paid at Hicksville, NY 11801 and additional offices. Statement of Ownership, Management and Circulation, October 5, 2005. CQ VHF, 25 Newbridge Road., Hicksville, NY 11801. Publication #1085-0708. Issued quarterly (4-times a year), subscription price $25.00 per year (4 issues). Publisher: Richard A. Ross; Editor: Joe Lynch: owned by CQ Communications, Inc. Stockholders: Richard A. Ross. Circulation (Average of Preceding 12 Months): Net Press Run 5,620, Mail Subscriptions 3,827, Sales Through Dealers and News Agents 969, Other Classes Mailed 0, Total Paid 4,796, Free Distribution 310, Total Distribution 5,106, Copies Not Distributed 514, Total 5,620. Circulation (single issue nearest filing date): 5,700, Mail Subscriptions 3,675, Sales Through Dealers and News Agents 885, Other Classes Mailed 0, Total Paid 4,560, Free Distribution 310, Total Distribution 4,870, Copies Not Distributed 830, Total 5,700 s/Dorothy Kehrwieder, Business Manager..
Printed in the U.S.A.

Postmaster: Please send change of address to CQ VHF Magazine, 25 Newbridge Rd., Hicksville, NY 11801

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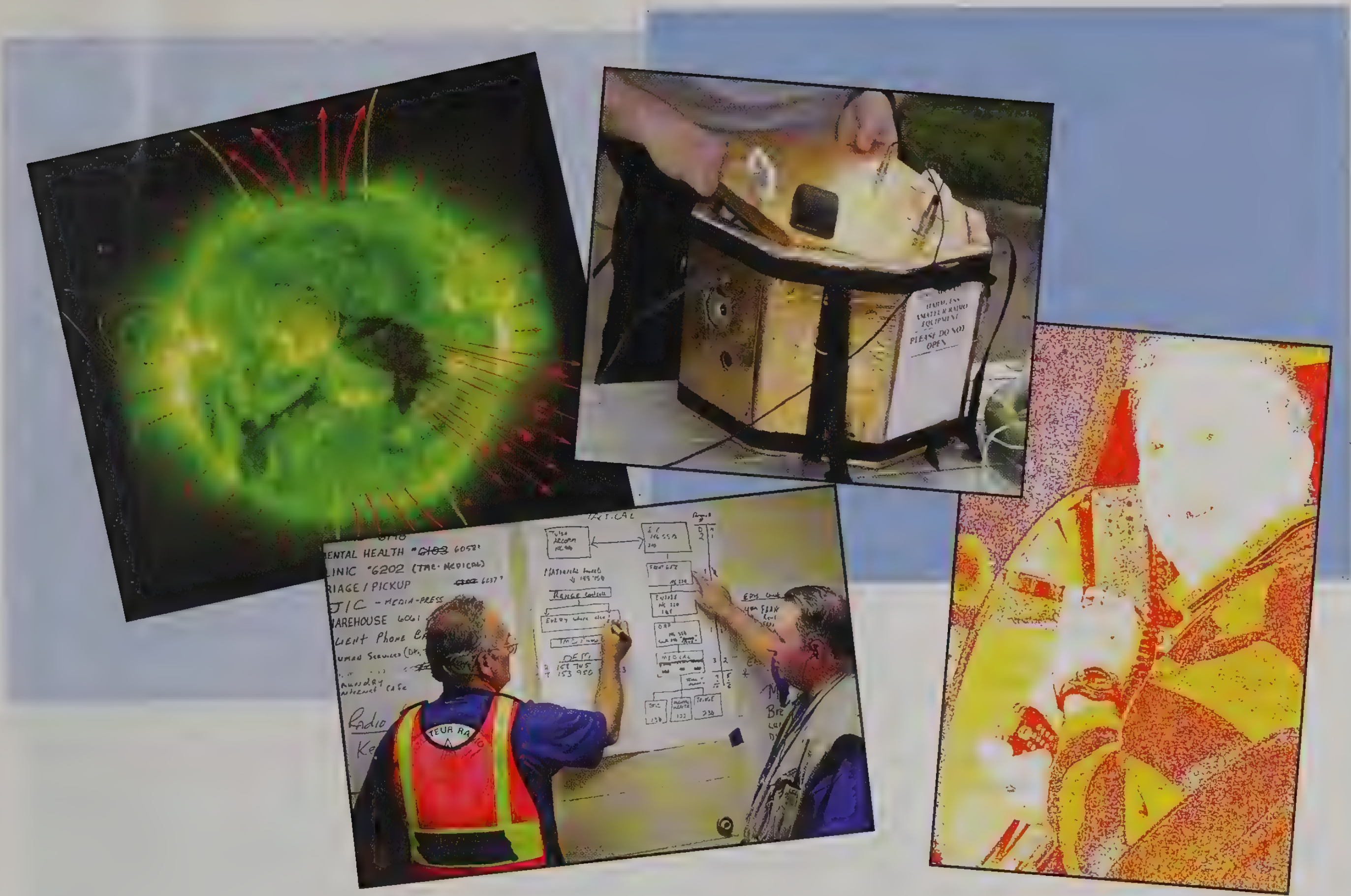
Fall 2005
Vol. 8 No. 3

FEATURES



COLUMNS

DEPARTMENTS

On The Cover: At the Great Plains Super Launch 2005, a team fills its 1500-gram weather balloon in preparation for flight. Left to right: Reporter from the *Omaha World-Herald*; Keith Kaiser, WAØTJT; Cindy Campbell, KCØRRW; and Mike Hackley, KCØSGD. For details see page 10. Inset: Premiering this month is "Airborne Radio," a column by K1UHF that covers controlling model aircraft via amateur radio; see page 21.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Emergency Communications: Amateur Radio's Evolving Involvement

During these past few months we have witnessed the use of our hobby as backbone communications in the aftermath of disastrous hurricanes. Amateur radio operators from all over the country have been pressed into duty in a variety of communications services.

Two such examples are described starting on page 6, where Mark Conklin, N7XYO, reports on Oklahoma amateur radio operators' involvement, both in rescue operations and in being the backbone communications for the Camp Gruber evacuation site. For the latter, amateur radio operations became critical at the Camp Gruber site, as the following quote illustrates:

> Shortly before 10 AM Sunday, Steve Palladino, an Emergency Management Officer for the Oklahoma Department of Emergency Management, arrived in the incident command. Oklahoma has spent millions of dollars on equipment that would allow interoperability of communications. When I asked Palladino if the interoperability communications trailer (known as ECHO 1) was coming, Steve told me that it was "out of pocket," which is what happened to many of the "first in" resources from some agencies in our area. "Out of pocket" means that they were deployed to the major disaster in the Gulf region. Palladino and I spent a few minutes covering where we had or would have operators. He said, "You guys are great. Thanks for jumping in to help." I asked him how long he would expect to need amateur radio. Palladino replied, "for the duration."

As Mark illustrates, a specific number of hams strategically placed within the evacuation center replaced a multimillion-dollar communications van. Plus, no doubt they provided more flexibility in handling the interoperability needs at the site.

The Baseline

In many respects, amateur radio emergency communications can look to the Oklahoma City Murrah building bombing as a baseline for measuring the assistance we can and have rendered over the years. Before the bombing, many times our involvement with various government and non-government organizations (NGOs) was by happenstance. Lack of experience in working with hams led to reluctance to use us, and in some cases outright mistrust of us and our intentions. These reactions were not unfounded, as sometimes we hams invited ourselves into the disaster communications situation without prior approval from or awareness of those government and NGO operators on the scene. Even with prior approval, sometimes those on the scene were reluctant to cooperate with us or use us.

Considering the latter, but for some serendipity such might have been the case in my emergency operations from the Oklahoma City Police Department mobile EOC van in the aftermath of the Murrah building bombing. When I arrived downtown, I was instructed by the emergency net control operator to report to the van and join the amateur radio operator already on board. While walking over to the van, I wondered how I was to explain to the police officers my being assigned to their van. My concerns were eliminated when Stan Van Nort, N5JFQ, greeted me at the door and invited me inside. Stan was one of the police officers operating the police radios, and his approval of my entrance set the other police officers at ease with my presence. After finding the location of the ham station, I immediately went to work with the other amateur radio operator, supplying information to the police as to the locations of the various NGOs inside the disaster perimeter.

The Aftermath

In the aftermath of the Murrah building bombing, we amateur radio operators who worked that disaster held a debriefing meeting a few weeks later at the Green Country Hamfest. One of the issues we discussed was what it was like to be so intricately involved with several government and NGO agencies at the same time. The problems of interoperability and even the various organizations' lack of knowledge of who was doing what inside the perimeter were among the topics we covered. Another issue discussed was the uselessness of cell phones in the immediate aftermath of the bombing. For us, it was very productive, and several of us later found out that many of the lessons we learned were implemented by the amateurs who responded to the September 11, 2001 terrorist attacks.

In the ensuing weeks and months following the disaster one item we noticed was that while the Salvation Army championed our involvement (both during and in the aftermath debriefings), there was still much skepticism by other NGOs, as well as the various government agencies involved in the disaster and its aftermath. Sadly, it was during the aftermath of the September 11, 2001 terrorist attacks when more and more government agencies and NGOs recognized—and even come to rely upon—our communications skills. Even so, widespread recognition was slow in coming.

Thanks to the huge education and lobbying efforts by the ARRL, we received the well-earned recognition and backing from the Department of Homeland Security. Now, Hurricanes Katrina and Rita have become our proving grounds. As Mark illustrates in his article, for the most part hams were and are responding very well. Even so, there continue to be a few instances of Lone-Ranger-type responses by hams who are not trained or prepared for emergencies. Such responses continue to hamper our increasingly positive image, which we should never stop presenting to the rest of the world.

We will have lots to learn from the many debriefings that will occur in the aftermath of these disasters. One item already being discussed is the problem of lack of interoperable communications between various responders to the disasters. What Mark tells us by way of his article is that interoperability of communications continues to be a major problem for emergency responders—and no doubt will continue to be problematic for quite some time to come.

The question for us hams is: Will we continue to be equipped to fill the void? I believe we can be. Furthermore, articles such as Mark's in *CQ VHF* can and will play a role in our emergency communications education. Therefore, I will be looking for these types of stories, as well as how-to articles related to emergency communications, for future issues of this magazine. I am especially interested in articles that describe the various creative ways in which the VHF-plus frequencies have been and can be utilized for emergency communications. Therefore, if you have a unique story to tell that will be of benefit to your fellow emergency-response amateur radio operators, please contact me with your story idea and we will give consideration to publishing it.

Until the next issue…

73 de Joe, N6CL

Oklahoma Amateurs Respond to Hurricane Katrina

In response to the devastation caused by Hurricane Katrina, hams all over the country were pressed into service to provide necessary communications. Here N7XYO describes the roles that Oklahoma amateur radio operators played, both in a rooftop rescue and in providing backbone communications at the Camp Gruber emergency shelter for persons displaced by the hurricane.

By Mark Conklin,* N7XYO

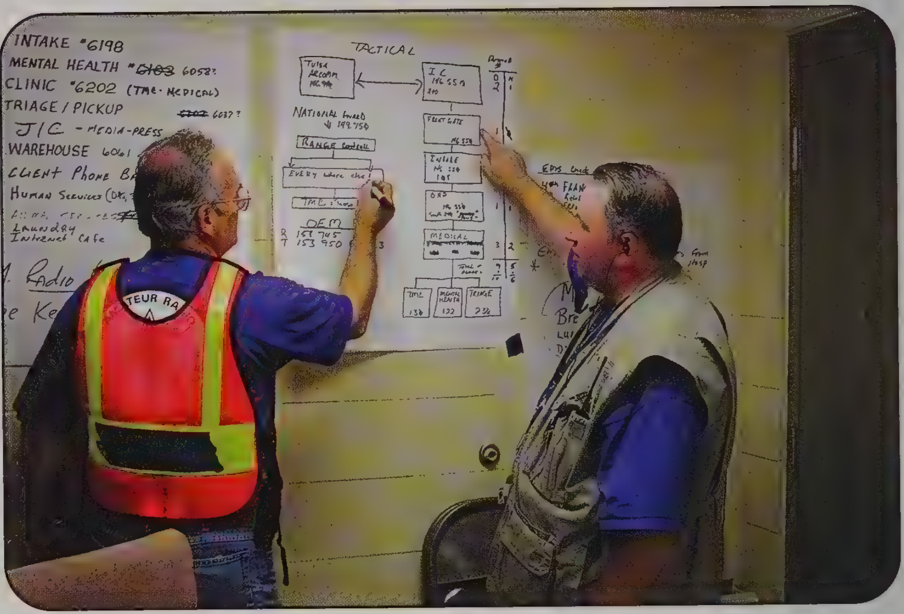
There were 15 people trapped on the roof of their home in New Orleans as the flood waters from Hurricane Katrina raged by on August 29. They clung to the roof and watched as others floated by in the rushing flood waters. They had a cell phone, but none of the local emergency numbers worked. They called a relative in Baton Rouge. Because the local emergency numbers in Baton Rouge also were not working, that relative called Sybil Hayes, a relative living in Broken Arrow, Oklahoma.

Hayes had been worried about her 81-year-old aunt and her cousins in New Orleans all day as she watched the coverage of the storm. She tried and tried to call her aunt, but all circuits were busy. Then her phone rang; it was the call from the relative in Baton Rouge giving her the news of her elderly aunt.

Sybil knew that the Red Cross could help, because the Red Cross had helped her family during a flood in 1995. She immediately contacted the Tulsa Oklahoma Chapter of the Red Cross.

The Tulsa Chapter of the Red Cross Emergency Services, which has a partnership with the Tulsa Repeater Organization (TRO is a Tulsa-area amateur radio group dedicated to public service), had a plan. Red Cross emergency services put the plan into action and contacted response team member Paul Papke, WB5MPU.

Papke is a Red Cross volunteer and an amateur radio operator. Papke then rounded up Ben Joplin, WB5VST, to help get the message through. Joplin immediately went to the Tulsa Red Cross Emergency Operations Center, which has a fantastic HF station ready for action.



Ed Compos, K5CRQ "NIC 2," and Mark Conklin, N7XYO "Command 1," review daily assignments and communications needs at Camp Gruber. (Photo by Fred Williams, KD5NBR)

Joplin made contact with net controllers on the Salvation Army Team Emergency Radio Network (SATERN) on 14.265 MHz. The emergency traffic went from Tulsa to Oregon to operators in Idaho to Amateur Radio Emergency Service stations in New Orleans, who alerted the Louisiana rescuers.

"When all else fails, amateur radio works" is more than a catchy tag line. It's a lifeline. At about 10 PM the Red Cross reported that Sybil Hayes's 81-year-old aunt and everyone on that roof were safe and at a Red Cross shelter.

This is only one of many such stories of Oklahoma amateur radio operators coming together to help save lives. Over the next few days, Doug Lee, KC5ZQM, public-service chairman for TRO, continued to recruit and schedule amateur operators to monitor traffic and pass emergency messages from the Tulsa Red Cross communications center to rescuers in the disaster area. Then the Tulsa Red Cross received word that Texas was full.

Texas is Full?

On Friday September 2, Oklahoma was notified that approximately 6000 evacuees were being sent from the Houston, Texas area to Oklahoma City and Tulsa. The Oklahoma Department of Emer-

*15152 Boren Road, Mounds, OK 74047-5301
e-mail: <n7xyo@arrl.net>

A portable mast system from Paul Papke, WB5MPU, made quick work of setting up at Camp Gruber. Notice the "fold-up" J-pole and push-up mast provided by Robert Coughlin, KE5BGX, which went up in a snap. (All photos by the author unless otherwise noted)

gency Management (ODEM) started working with emergency managers and the mayors of both cities to form an emergency-reaction plan.

Rather than house the evacuees inside convention centers or other large buildings that had not been designed for that purpose, the plan was that evacuees would first be sent to Camp Gruber in Braggs, Oklahoma and to Falls Creek church camp in Davis, Oklahoma, located in the southern part of the state. Camp Gruber is an Oklahoma National Guard Training campus in the eastern part of the state.

The Red Cross would run shelter operations at Camp Gruber; Baptist Men's Disaster Relief Ministers would operate the shelter at Falls Creek. Because many of the displaced victims did not want to take another bus ride to anywhere else (after traveling from New Orleans to Baton Rouge and then to Houston), the Falls Creek camp was prepared to accept evacuees, but they never received any. Camp Gruber did.

Amateur radio's initial mission was to maintain a back-up communications link from Camp Gruber to the communications center at Red Cross in Tulsa, some 65 miles northwest of the camp. Late in the evening on Friday and into the wee hours of Saturday, we sent amateurs to Camp Gruber to set up that link. Ed Compos, K5CRQ, made contact with Red Cross Shelter Manager Janell Mullinax and then set up communications inside the incident command center in building #240 of the camp. Using a dual-band VHF/UHF radio, we were able to maintain contact with the Red Cross in Tulsa via the 146.940 TRO repeater in Tulsa. As a back-up to that, the 443.100 Muskogee repeater linked via the Tulsa Amateur Radio Club (TARC) super-link to the 443.850 repeater in Tulsa. To make sure we could contact the state EOC in Oklahoma City, we set up an HF system with an FT-920 and a G5RV antenna. Things seemed to be covered. In any emergency communications operations, events tend to be fluid. It was about to pour at Camp Gruber.

The Guests Arrive

Shortly after 10:45 PM on Saturday, September 3, 39 bus loads of tired and hungry evacuees began to arrive at Camp Gruber. Many of these people needed medical attention. More than 40 ambulance runs from the camp to area hospitals were required. It quickly was discovered that this was going to be more than a shelter operation. This was going to require a full disaster response. It also was discovered that many of the agencies responding could not communicate with one another.

Many phone and communications systems are designed for some of the people to talk some of the time. In an emergency or disaster, everyone wants to communicate at the same time. Camp Gruber was designed as a National Guard training campus, and some of the buildings have telephones and some do not. The phones that were there operated on a Voice over IP (VoIP) phone network, and when overloaded they crashed.

Because I am the club president of TRO, I ended up as the amateur radio emergency communications leader for this response. During the night (now Sunday morning of September 4) my home phone and cell phone rang all night long with status updates or requests for additional communications support. As daylight began to shine on Camp Gruber, I and a number of additional amateur radio operators were on the road and en route to help at the camp. I contacted our team at Red Cross HQ. I instructed them to round up more volunteers and ask a few more to stand by to respond.

As I drove through the main gate at Camp Gruber, things seemed odd. The camp had the look of many other disasters I had responded to: ambulances with lights flashing, Oklahoma Highway Patrol cars everywhere, Red Cross vans, National Guard troops, and all sorts of responding agencies. What was odd was that all the buildings were neatly numbered and painted, the grass was mowed, and street signs were all clearly visible. It was a strange mix of order and chaos.

I walked into the Incident Command center in building #240 and got fewer than ten steps across the floor when I made contact with a Tulsa Police Officer, Rick Bondie. Bondie, a member of the Tulsa disaster response team and the Oklahoma Department of Emergency Management (ODEM), had dispatched the Tulsa disaster response team to Camp Gruber to take over operations. I had worked with him on other disasters and in training. Bondie and I stepped into a conference room and he gave me a quick briefing. He requested amateur radio support to ensure that all the responding agencies could communicate with one another and all the critical points at the camp had communications.

We were about to grow from three volunteer amateur radio operators to nine, 24/7, for who knew how long. This response was going to take more structure and effort than most public-

(Continued on page 76)

Some Thoughts on Being Prepared for an Emergency

The recent natural disasters have taught us hams that we need to be prepared to render emergency communications—sometimes at a moment's notice. Here WB2AMU discusses some preparations that can be made.

By Ken Neubeck,* WB2AMU

Having lived on Long Island, New York all of my life, on occasion we have had severe hurricanes that have caused extensive damage to the area with winds causing power loss as the result of blown-down power lines. One thing that I cannot stress enough is being thoroughly prepared for a natural disaster such as a hurricane, when typically one has at least two days to prepare.

One experience that I vividly remember occurred on the evening prior to Hurricane Belle's arrival in August of 1976. As a young ham I helped another local ham set up an 80-meter amateur radio station at the local Red Cross headquarters in my town. Although Belle was only a Category 1 hurricane, at that point it was the most damaging hurricane to hit Long Island since Hurricane Carol in 1954.

It took about 30 minutes to set up the 80-meter antenna outside of the headquarters building in the rain and then set up the station inside the headquarters building. The 80-meter station was to be used to interface with other amateur radio groups in the Northeast region. In the meantime, I had a 2-meter setup in my car and I checked into the local 2-meter emergency group with a quick call. The ham I was helping was not particularly interested in 2 meters being another source of communication, as he was concentrating on the 80-meter station. However, as much as he thought that he had the situation under control, he made a number of rookie mistakes that eventually made the 80-meter station useless during the hurricane that came into the area later that night. These mistakes were:

1. He had not formally introduced himself to the local Red Cross group ahead of time to explain how ham radio would be of help during an emergency. The ham operation seemed like an intrusion to the group.

2. He had neglected to bring headphones, and thus the audio from the 80-meter station was causing interference to the Red Cross people, preventing them from listening to their radio and further adding to their annoyance.

3. Most important of all, the 80-meter station was running on commercial AC power, and he had neglected to bring a portable power source such as a generator or battery bank and thus . . . When power went out at midnight, both the 80-meter station and the Red Cross station were rendered useless for a few days until a generator was finally brought to the headquarters.

Field Day is an ideal time for learning how to set up a radio station during emergency conditions. This photo shows the 6-meter antenna as one of the several VHF stations that were set up for the 2005 Field Day effort of the Peconic ARC on the north fork of eastern Long Island. In addition to Field Day, the club participates regularly in simulated emergency exercises such as the ARRL SET events to keep up the level of preparedness. (Photo by WB2AMU)

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The ham radio operator in charge had no Field Day experience, nor did he do much in the way of VHF operation, such as 2-meter FM. Looking back at this particular incident many years later, I can see that as a minimum, any ham who has plans to help out in an emergency should have some practical experience in setting up an emergency station (either for Field Day or VHF portable operation). While HF is one important aspect of communication, it is just as important to have either an all-mode VHF station or a properly operating FM HT.

Each disaster is different. Sometimes there will be a shelter for the ham radio station and sometimes there will not be one. I would like to think that the ham who has had experience with portable operation in the field can either set up from his or her car or in shelter running battery power.

It is most likely that 2 meters will be the logical band for carrying on local coordination, with FM being the mode that most hams will have access to. I think that alternative VHF bands such as 6 meters and 432 MHz could also be used for non-essential communications. In addition, VHF SSB should not be ruled out. HF in the area of 80, 40, or 20 meters will serve a purpose for long-range communications to other states or regions for obtaining any needed medical and logistical supplies.

In my opinion, participation in Field Day is one of the best ways hams can prepare for emergency operations. You learn many things from participating in a number of Field Day events. For example, one thing most hams do is bring headphones for a multi-transmitter operation to lessen the impact of audio noise from stations adjacent to one another. I also feel that those hams who do both rover and portable operations during VHF contests, as well as SET (simulated emergency tests), are doing well in improving their skills!

With a storm such as a hurricane, there is usually a warning at least two days in advance. All batteries for your HTs should be charged, and your vehicle's gas tank, as well as additional tanks (but be careful where you place them), should be filled. The VHF or HF station that you plan to use should be up to operating snuff and easy to remove for portable operation. If you have not already joined up with an emergency group, find out right away which group is in charge. If there is none, form a group with local hams and work out the procedures ahead of time.

This year Hurricane Katrina caused a great amount of damage and tragedy for so many. I am certain that ham radio will continue to distinguish itself as a vital resource during the months of rebuilding ahead. Perhaps, too, as people continue to see the good that amateur radio can do in times of emergency, there will be an increase in the number of those who want to join our ranks. It is important that the public see a well-prepared amateur radio response, and this is gained from practical experience. All hams would do well to think outside of their base stations and be capable of setting up a VHF station in a portable manner. ■

CAPNSPACE
(Civil Air Patrol Near Space program)

This past July via the Great Plains Super Launch, GPSL-2005, ten groups launched balloons from Traynor, Iowa. Here KCØMIC tells his story.

By Troy Campbell,* KCØMIC

We had three "firsts" this year. (1) This flight marked the first flight made at a GPSL (Great Plains Super Launch). Last year we only observed at GPSL-2004 in the hopes of starting a program. (2) It marked the first flight CAPNSPACE made as a member of the Near Space Ventures group. In conjunction with that, we worked with a Boy Scouts of America venture group. (3) It was the first flight that we recovered without any "outside assistance" (i.e., the farmer didn't find it before we did and call us).

Launch

At 7:00 AM we arrived at Traynor High School and began setting up. The winds were still light and it was about 70°F. After another group had began to fill their launcher (balloon), we noticed that the wind was just starting to pick up. We decided that we would fill our balloon and be ready for launch should the wind start to pick up any more. It also was decided that we'd put in more lift than we normally would to get the package out of the ground winds and past 40,000 feet faster than normal.

We launched at 8:10 AM CDT, about five minutes after the first launch. The climb rate was about 1100 fpm (that's an estimate until the data from the flight recorder can be analyzed). We packed up and split into three teams, leaving the launch area right after five more teams launched their balloons.

Tracking

The APRS (automatic position reporting system) telemetry showed that the flight path was following the flight projection fairly closely. Almost immediately after takeoff, the tracking system froze up for chase Team 1. Team 3's tracking equipment never did work. Team 1 rebooted and got some limited functionality for maps and vehicle location, but the KPC 3+ TNC (terminal node controller) stopped working altogether. Chase Team 2's equipment was working perfectly.

At this point, Teams 1 and 2 departed east on highway 92 to highway 71 to stay ahead of the balloon. Team 3 remained to try to get the tracking system working. The 2-meter simplex repeater on board the spacecraft worked great, so all the teams stayed in contact . . . up to a point.

The spacecraft is equipped with an ELT (emergency locator transmitter) on a practice frequency of 121.775 MHz. Every five minutes the flight-control computer would turn on the ELT for one minute. When the spacecraft neared apogee,

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The launch crew attaches the payload to the launch vehicle (balloon). Left to right: Cindy, KCØRRW (Captain, CAP); Keith, WAØTJT; Troy, KCØMIC (Major, CAP); and kneeling, Mike, KCØSGD (Major, CAP). (Photos by Deb Kaiser)

the flight controller latched on the ELT so that it could be tracked on the way down.

The problem was that the ELT modulated the 2-meter simplex repeater. We still don't know if the issue was the proximity of the antennas, or if the ELT or 2-meter transmitter needed to be shielded, or both, or all three. In any case, when the ELT latched "on," the simplex repeater became pretty much useless. It would still key up, but whatever voice traffic was on it was drowned out by the ELT. Because of that, Teams 1 and 2 lost contact with Team 3 about an hour into the flight.

Troy, KCØMIC, readies the payload—near-spacecraft—for flight.

Another GPSL teams prepares for launch.

The tracking equipment of Team 2 (Keith Kaiser, WAØTJT, and Deb Kaiser) was still working fine, so Team 1 (Troy Campbell, KCØMIC, and Cindy Campbell, KCØRRW) stayed within simplex range and both teams stopped just outside Grant. The balloon had pretty much stopped its forward motion over Elliot, and it climbed to 95,082 feet and burst just a little west of Elliot. What was interesting was that if we kept the meter on the ELPER (an emergency locator receiver that is used to determine the position of the ELT) "centered," we could get a fair sense of the elevation as well as the direction. The DFing fixes agreed with the APRS data, which was gratifying. I was worried that we wouldn't be able to track it with only one set of APRS equipment. The ground teams departed for a position between Elliot and Grant.

Recovery

Keith on Team 2 had binoculars and spotted the balloon at about 3000 feet after it had passed over us, but lost it over a hill. The last APRS position was from 2400 feet at a little past 10:00 AM CDT. We left for that spot. Team 2 was already there and searching a corn field (Iowa = corn, and we probably should have guessed the landing obstacles). Joe Lynch, N6CL, editor of *CQ VHF*, was also on the scene to help with the search.

After a while I broke out the ELPER and took a couple of fixes on the ELT. It was still strong, showing the signal coming from farther north, but basically straight up the road. If you look at the track from the APRS data, you'll see that the package flew up the road and landed within 20 feet of the balloon (for more information on the APRS date, see <http:// www.capnspace.org>). Unfortunately, the corn was taller than I was and the fence propagated the signal in many wonderful ways.

Even though the ELPER was pointing to the package correctly, the terrain was very hilly with intermittently space tree lines, creeks, and terrace ridges. The owner of the farm arrived about midway through the search and attempted to help from the top of his almost two-story harvester, but it was on the ground in the tall corn and just couldn't be seen.

After about $2^1/2$ hours we'd narrowed down the location of the package to a 50-foot patch of corn using an aircraft radio and "body nulling." When I couldn't get a null any longer, I took the antenna off the radio, held it away from me and par-

(Continued on page 58)

Photo of near space taken by the camera on board the payload of the CAPNSPACE balloon. (Photo by KCØMIC)

10 GHz and Up
Liaison Frequency Observations

As witnessed by this past summer's ARRL 10 GHz and Up Contest, the 10-GHz amateur radio band is enjoying increasing popularity. In this article, WB6NOA describes how members of the San Bernardino Microwave Society, and others, are handling the increased activity in their area of the country.

By Gordon West,* WB6NOA

The recent ARRL-sponsored 10 GHz and Up Contest saw more coast-to-coast microwave activity than ever before. In anticipation of wall-to-wall signals on 10 GHz in southern California, fixed and rover stations staked out frequency claims ahead of time! Here is just a small list of how the San Bernardino Microwave Society (SBMS@hamradio.com) spread out its coordinated operations:

Baja Mexico	10,368.450 MHz
Signal Hill, near L.A.	10,368.380 MHz
Frasier Mountain, north of L.A. valley	10,368.525 MHz
San Diego mountaintops	10,368.200 MHz
An island off southern California	10,368.475 MHz
San Bernardino mountains east of L.A.	10,368.400 MHz

Mountaintop rovers also pre-announced their favorite X-band frequencies.

The author's new 10-GHz antenna for dune-buggy mobile.

Throughout the country, 10-GHz teams met at elevated hot spots and consecutively operated their own individual equipment to increase activity, scores, and the personal satisfaction of maximizing the total count of stations each person's little milliwatt rig had worked. The big signals and big dishes went first, allowing the distant station to lock frequency as well as bearings. The team stations then came on individually, usually going from higher power stations down to the pipsqueak stations that ultimately would be heard because all of the team members helped set the direction of the path.

"Multiple team stations helped out one another by letting the lowest power station come into rotation as a long path was beginning to peak," comments Bill Alber, WA6CAX, operating out of the Bay Area.

BadgerContesters (badgercontests-request@mailman.qth.net) echoed the same technique with big-dish, high-power, 10-GHz stations becoming the *moderator* and assisting their hillside team members in establishing a contact when conditions got rough.

The Liaison Frequency Connection

Until this year, the likelihood of establishing a 10-GHz QSO "in the blind" by calling CQ on 10,368.100 MHz would have been pretty slim. Unlike 144.200 or 432.100 on VHF/UHF SSB, your chances of hooking up with another station that just happened to be on the same frequency and pointing in your direction as you pointed in their direction are hit or miss—more than likely, more miss than hits! Hence, the liaison frequency.

Liaison frequencies likely are 2 meters or 70 cm with your handheld hanging on the dish. Everyone in the area must agree on the liaison frequency, whether it is simplex or duplex through a series of linked repeaters or a single repeater. In southern California linked repeaters were a necessity for some of the nearly 1000-km paths that were being worked on 10 GHz. (Twenty years ago, liaison was on 144.330 MHz simplex for the coordination of our wide-band FM 10-GHz contacts, which rarely exceeded 300 miles!) Even so, there are problems.

While the linked UHF repeater systems worked well for the range extension necessary for distant-station coordination, the combined repeater links, skillfully mixed to eliminate unintelligible doubling, were a test of each operator's skill in listening simultaneously to three or four conversations!

"Everyone was stepping on one another over the coordination channel," comments Bill Alber, WA6CAX, listening in on one of the California links. "Mexico was coordinating with Kettleman, Frasier was talking to Gordo maritime mobile, Site 51 was coordinating with San Diego, and La Canada was looking for any contacts aimed west. This was all going on simultaneously," adds Alber, pleasantly surprised that the liaison instructions indeed got through after a couple of times, and everyone took the QRM as being the way liaison communications take place on linked repeaters.

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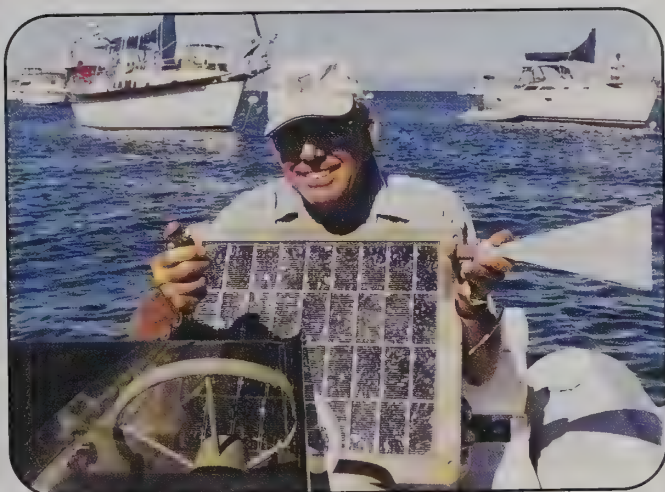
WB6NOA's 10-GHz maritime mobile setup. One watt and 300-plus miles to Mexico makes him smile!



Tom, N6DCL, uses a horn antenna with 1 watt over a 100-mile path.

"Maybe we need an NCS (net control station) who is an experienced microwave operator and is also experienced in coordination and control operator duties," adds Art, KC6UQH, a seasoned 10-GHz homebrewer. "This net controller would not be out operating, but rather paying attention to all the traffic on the band and expertly keeping liaison comms flowing," adds Art. Art feels that each station should check in and out with NCS; the NCS will need to be microwave-knowledgeable so a station checking *in* can be advised on an appropriate contact to try next and then send him off to a particular X-band frequency and approximate bearing.

"Yes, the liaison system is in need of improvements. The net control will solve most of the current problems by knowing who is looking for contacts, who is enroute to another site, who had a dish fall over and is now QRT, and who has a carrier on the air and on what frequency," adds Art. "A net control will reduce continuous chatter. The good net controller can also cut the idle chatter on the liaison frequency, such as a discussion on 3 dB of noise coming out of a local palm tree."

Art further reports that once he starts making contacts on 10 GHz he shuts off the liaison radio. "If I know at 10-minute intervals the net control station will give the status of contacts in progress, and operators looking for contacts, I do not need to continuously monitor the liaison frequency and have that chatter disrupt my train of thought in making a long-range, 10-GHz QSO," adds Art.

"I lost many contacts last year because I was unable to raise anybody at a known group location on the liaison channel—frustrating when I know that a few hundred points worth of contacts are right there if only they would answer the liaison radio," adds Mel, WA6JBD. "It takes considerable effort to repeatedly pack up and move. The liaison contacts must get through with a minimum of repeats and an absolute minimum of unanswered calls by other stations that could likely be easily worked over a long path."

"Maybe it's time we consider the 10-GHz contest operations the way we would consider operating during a 20-meter SSB DX contest. There is so much great activity on the 10-GHz band that we can tail-end stations, work pile-ups, and wait on frequency to see if there are other stations to work," comments Doug, K6JEY. "I think we need to expand our 10-GHz operating procedures to a dual mode where we use both the liaison and low-band techniques, such as tail-ending, calling QRZ or CQ, and listening after a QSO for other stations that might be calling," adds Doug. Several 10-GHz East Coast microwave groups regularly call CQ on 10,368.100. They also say it's common to stand by on "your" assigned frequency and let someone else tail-end

on a contact you've just made, and let them make it.

"I like the idea of calling CQ with a horn. Chances are you'll snag more stations," comments Robin, WB6TZA.

Wayne, KH6WZ, echoes some of the techniques on low band that might be employed up on 10 GHz without the necessity of calling out on the crowded liaison frequency. Wayne says to look at the book *The Complete DXer* by Bob Locher, W9KNI. "This book is in its third edition and reads more like a novel rather than a textbook," adds Wayne, underscoring the importance of good operating technique on microwave being even more important than a big dish or a traveling wave tube.

"I always call QRZ after making a contact. It is far more efficient for stations to listen to a QSO in progress and come in after it rather than trying to call up on UHF for liaison," adds Jeff, WA6KBL. "Save the UHF liaison for only those situations when you can't possibly hear the other station without putting up a carrier and aligning both ends. *There are far too many S-9 contacts that take too long because each end sits on X-band with a carrier for a minute at each end, making a total of 2 minutes before the QSO is even made,"* adds Jeff.

"The liaison link gets very busy with many stations overlapping one another. If your audio is low, you might not be heard amidst all the chaos. Have someone check your audio level compared to others on the link," comments W6BY. "Another trick—get to know the people in the club you are working on 10 GHz. If people can associate a face with a call, they respond better," adds W6BY.

"*Most important,* when operating through a repeater or linked repeater system, you need a pair of radios to run full duplex so you can hear yourself over the link to make sure you are not taken out, or doubled, or captured by another station," adds Mel, WA6JBT, indicating his link radio is a mobile in the front of the rig, another mobile near the X-band rig, and even an HT. As a double check he hears himself through the link when activity is high, which is usually all the time!

Finally, the link issue touches some sensitive areas, such as "secret" repeater and link frequencies so just chosen stations can coordinate over long paths, putting newcomer local stations out of the loop. Or worse yet, coordination via cell phone, which indeed negates the friendly ham radio party-line exchanges so everyone else knows what's going on.

Maybe a net control station would assign liaison non-linked repeaters that would cover a specific path with an announcement on the 'main' channel that X and Y will spend the next 15 minutes on a certain repeater attempting to establish a link, and any and all stations are invited to join in after the initial contact is made.

Finally, part one of the contest found me maritime mobile, and while working the link was certainly important, I found that operating the little horn and aiming it at a distant island with an initial callout on the link frequency that I would be calling CQ on .100 was a great way to attract attention and give out additional water grids.

What ideas does your group have for establishing liaison links for 10 GHz and up contacts? ■

Swinging the Dish

The bigger the dish, the more precisely you must aim it over long paths. I found this out quickly with my new Prodelin .84-meter Ku-band antenna. The feed horn was a precision upgrade for 10 GHz, thanks to Art, KC6UQH.

"Bring a compass and use it! When I am careful in lining up the dish, 99 percent of my contacts are aimed right where they are supposed to be," comments Art, advising me that the new dune-buggy-mounted dish will be much more precise than my traditional Casagrain aluminum dish.

However, beside proper azimuth aiming of a dish, the 10-GHz operator needs to always monitor his relative dish elevation.

"On aiming, don't forget to look *up* a little. Long paths are often enhanced by the Boeing effect, and that effect can peak above the horizon by a couple of degrees," comments Robin, WB6TZA, speaking of the common occurrence of aircraft 10-GHz scatter signals.

"I have worked dozens of contacts and can enhance some of the other long hauls by an enormous amount by slight azimuth realignment and a 2-degree uptilt to maximize signals," adds Robin. "This does not mean that an oblique angle cannot be used. It is just much more difficult, as both stations have to track a moving target that is probably much closer than those used in a 'forward' direction."

Thus, on your next 10-GHz outing do some air-traffic chart calculations, and give your system a 2-degree uptilt to see whether or not you can take advantage of the Boeing effect!

QUARTERLY CALENDAR OF EVENTS

Current Contests

November: The second weekend of the **ARRL 50 MHz to 1296 MHz EME Contest** is November 12–13.

January: The **ARRL VHF Sweepstakes** is scheduled for the weekend of January, the 21–23.

For ARRL contest rules, see the issue of *QST* prior to the month of the contest or the League's URL: <http://www.arrl.org>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. The following organization conference organizer has announced a call for papers for its forthcoming conference:

EME Conference 2006: The EME Conference 2006 will be held in Wuerzburg, Germany on August 25–27. Interested authors are invited to present a paper(s) for the conference. Electronic submissions in Word97, Word2000, Acrobat5 (PDF), or text format will be accepted by e-mail or on CD. Please ask if you are using another format.

If you are interested in writing and/or presenting a paper for the EME Conference 2006, send an e-mail to Rainer Allraun, DF6NA, at: <df6na@df6na.de>. Please contact him as soon as possible with an abstract or even a general idea. This will help the conference team with its planning activities. For more information about the EME Conference 2006 see: <http://www.eme2006.com>.

Meteor Showers

November: The *Leonids* is predicted to peak around 1430 UTC on November 17.

December: Two showers occur this month. The first, the *Geminids,* is predicted to peak around 0224 UTC on 14 December. The actual peak can occur 2.5 hours before or after the predicted peak. It has a broad peak and is a good north-south shower, producing an average of 100–110 meteors per hour at its peak.

The second, the *Ursids,* is predicted to peak around 1053 UTC on 22 December. It is an east-west shower, producing an average of greater than 12 meteors per hour, with the possibility of upwards of 90 at its peak.

January: The *Quandrantids,* or *Quads,* is a brief, but very active meteor shower. The expected peak is around 1620 UTC on January 3. The actual peak can occur three hours before or after the predicted peak. The best paths are north-south. Long-duration meteors can be expected about one hour after the predicted peak.

For more information on the above meteor shower predictions, see Tomas Hood, NW7US's propagation column on page 69 in this issue of *CQ VHF.* Also visit the International Meteor Organization's website: <http://www.imo.net>.

Quarterly Calendar

Nov. 2	New Moon
Nov. 6	Very poor EME conditions
Nov. 9	First Quarter Moon and Moon Perigee
Nov. 13	Good EME conditions
Nov. 16	Full Moon
Nov. 17	*Leonids* Meteor Shower Peak
Nov. 20	Poor EME conditions
Nov. 23	Last Quarter Moon and Moon Apogee
Nov. 27	Moderate EME conditions
Dec. 1	New Moon
Dec. 4	Very Poor EME conditions
Dec. 5	Moon Perigee
Dec. 8	First Quarter Moon
Dec. 11	Moderate EME conditions
Dec. 14	*Geminids* Meteor Shower Peak
Dec. 15	Full Moon
Dec. 18	Moderate EME conditions
Dec. 21	Winter Equinox and Moon Apogee
Dec. 22	*Ursids* Meteor Shower Peak
Dec. 23	Last Quarter Moon
Dec. 25	Moderate EME conditions
Dec. 31	New Moon
Jan. 1	Moon Perigee. Poor EME conditions
Jan. 3	*Quadrantids* Meteor Shower Peak
Jan. 6	First Quarter Moon
Jan. 8	Moderate EME conditions
Jan. 14	Full Moon
Jan. 15	Moderate EME conditions
Jan. 17	Moon Apogee
Jan. 22	Last Quarter Moon. Poor EME conditions
Jan. 29	New Moon. Moderate EME conditions
Jan. 30	Moon Perigee
Feb. 5	First Quarter Moon; Moderate EME conditions
Feb. 12	Good EME conditions
Feb. 13	Full Moon
Feb. 14	Moon Apogee
Feb. 19	Poor EME conditions
Feb. 21	Last Quarter Moon
Feb. 26	Good EME conditions
Feb. 27	Moon Perigee
Feb. 28	New Moon

—EME conditions courtesy W5LUU.

VHF+ Roving
Part 2 – Roving in General and Station Configuration

In this second part of their two-part article (see the Summer 2005 issue of *CQ VHF* for part one), ND2X and N4FLM give an overview of roving and discuss the proper and efficient configuration of the rover station.

By Paul S. Goble,* ND2X, and Wayne Gardener,† N4FLM

The four main functions involved in roving are driving, navigating, operating, and logging. For the "shoot 'n' scoot" rover, operating includes functions similar to those used for Field Day, such as raising/lowering antennas, operating generators, etc.

Roving in General

Driving: Note that the first function on the list of roving functions is driving. Do this properly or risk your life! This is not a threat; it's a statement of what could very easily happen if a rover doesn't do it right! Whether traveling between stops or on a full-effort mobile-in-motion rove, keeping the rubber between the lines and the shiny side of the vehicle up is paramount! Piquing the ire of local gendarmes is also to be avoided; nothing ruins a roving budget more needlessly than a stiff traffic fine. Perhaps more important, stopping to talk to law-enforcement personnel can ruin a schedule—hi!

All the standard "going on a trip" preparations apply to roving. The vehicle must be mechanically sound and all fluids should have been checked and where applicable changed or topped off. Tires must be in good condition with good tread and proper air pressure. The success of the rove depends more on the vehicle than any other single factor. To illustrate, on the ND2X 35 grid effort in September 2000, 43 miles west of Grand Forks, North Dakota the ND2X "run 'n' gun" rover ceased to rove. The engine temperature was rising to unacceptable levels. This is bad enough for a gasoline engine, but it can be the death knell for a diesel engine! Only nine grids had been activated up to that point, and it was still relatively early on Saturday. KD5ABM was driving for us as a "non-operator," and his background as a diesel mechanic proved to be invaluable. He was able to determine the cause—a thermostat stuck shut, and thankfully that was a "roadside fixable" problem. It did cost over three hours for diagnosis and to let the engine cool sufficiently. The top cooling-system hose was then removed from the thermostat housing and a long screwdriver was used to jam the thermostat open permanently. There were no further cooling problems for the rest of the trip!

This problem didn't stop the rove, but it did cost the time required to activate as many as three additional grids! Had it been the fan clutch or water pump, ND2X would have had to drop out of the contest instead of merely missing out on three grids at the end of the contest because the contest time had expired. What a disappointment dropping out would have been!

Navigating: Knowing where one is going is imperative. This begins with a serious map study. All aspects of road and infrastructure parameters must be considered. There are differences in routing for the two roving modes (shoot 'n' scoot and run 'n' gun).

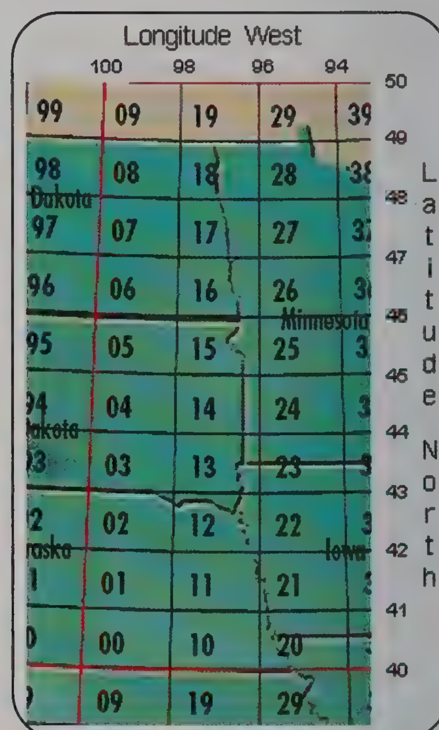


Figure 2. For the ND2X 35-grid effort, the east-west travel was from the far southwest corner of EN28, across 96 degrees longitude and EN18 to 98 degrees longitude and EN08. The route north to EN28 was along 96 degrees longitude.

For shoot 'n' scoot rovers it is necessary to identify locations at which five to six hours of parking and operating would be possible without stirring up any park personnel or park rangers who might happen on the scene. Most often "site sur-

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veys"—i.e., short day trips to investigate potential contest operating locations—are required. Any point of terrain advantage, from actual mountaintops to the high bridges and interstate overpasses, qualifies. Each location is rated according to the coverage it provides. It must be determined what directions to what grids are possible from a given location. One location might be great on certain bands but not very good on others. Another location might be excellent in certain directions but blocked by heavy, RF-absorbing vegetation in others. Sides of mountains can provide superlative coverage, except, of course, for the directions blocked by the mountain itself. Some locations preclude parking within 50 feet of the roadway. Each has good points and bad points, and each must be evaluated considering what is required of that particular spot during a given contest.

Routing between operating locations must be determined carefully. The shortest route in terms of time, if not distance, between two points must be selected to minimize the amount of time lost to travel. Here again, if possible, running the course once or twice before doing it during the contest can be a major help in avoiding the unexpected during a rove. Closed roads, bridges out, construction delays, and the like all contribute to ruining otherwise beautiful plans!

For run 'n' gun rovers, running the course beforehand may be impossible, as it was for the ND2X 35-grid run 'n' gun effort. In this case, hams living along or near the chosen route are consulted for "on the scene" reports. When planning a multiple-grid effort, selection of north-south roads close to even longitude lines is important. This, in terms of distance driven, effectively gives "two for the price of one," as the route provides access to grids on both sides of the even-longitude line as north-south travel is accomplished. If the number of grids activated is large enough, *some* east-west travel is unavoidable; there are only 23 grids from Brownsville, Texas north to the Canadian border. For a rover to activate more than 23 grids, then, travel from one even-longitude line to another is unavoidable.

As in north-south travel, and an east-west route should be chosen as close as possible to a "whole number" latitude line to be as close as possible to the demarcation (latitude) line between grids. Grids are just short of 70 miles north-south, but vary from over 124 miles wide at Brownsville to about 91 miles wide at the Canadian border. This shows that east-west travel between even-longitude lines should occur as close as practical to the northernmost point of the chosen roving route (see figure 2).

For the ND2X 35-grid effort, the east-west travel was from the far southwest corner of EN28, across 96 degrees longitude and EN18 to 98 degrees longitude and EN08. The route north to EN28 was along 96 degrees longitude, allowing activation of EN25, EN15, EN16, EN26, EN27, and EN17, in turn. It was necessary to dash east from the EN17-EN18 crossover into EN28, where a 20-minute stop was made before turning around and proceeding westward.

Map Studies: While the old standby, the Rand-McNally road atlas (or equivalent), is indispensable to both preparatory map studies and the travel itself, software aids exist to help in both aspects of navigating. ND2X likes the DeLorme (http://www.delorme.com/) products "Topo" and "Street Atlas." A tremendous amount of detail is available for a given route or site, and the ability to zoom in for closer inspection with the option to have lat-lon grid lines present on any map makes the DeLorme products particularly attractive. These programs also work well with GPS data if a GPS receiver is interfaced with the computer in use. When in motion, it is sim-

Photo G. Some shoot 'n' scoot rovers operate between portable operating locations, but generally only on 6 meters, 2 meters, and 135 cm due to the foliage-limited propagation at higher frequencies.

ple to determine vehicle location and the relationship at any given time to the next planned turn or stop by watching the progress on a laptop computer. In addition, the exact location of maidenhead grid boundaries can be seen at a glance. DeLorme also has an inexpensive GPS receiver designed specifically for its mapping applications and laptops; the latest version interfaces via a USB port. These are not the only products available, but this is what is used and, therefore, what is discussed here. It is a certainty that other sources can provide this capability, depending on personal preference.

Operating: This aspect of roving is primarily driven by personal preference. Equipment is configured to best support individual likes and dislikes, as well as the roving mode employed. In a like manner, division of responsibility is a matter of personal preference. ND2X likes to drive and operate the radios while someone else logs and navigates. Even so, on the ND2X 35-grid effort driving and navigating were paired, as were operating and logging. N4FLM, on the other hand, does not operate at all between his selected operating locations. It's not that he couldn't, but he chooses not to for safety's sake. Some shoot 'n' scoot rovers *do* operate between portable operating locations, but generally only on 6 meters, 2 meters, and 135 cm due to the foliage-limited propagation at higher frequencies (photo G).

There is one "fly in the ointment" regarding rover operations: Current ARRL contest management is adamant that drivers, even if they never touch anything having to do with communication equipment or logging, count as operators for a roving station. This becomes a safety issue, since only two operators are allowed for a roving station. In 2000 the ARRL told us drivers did *not* count as operators. Even so, with only three people in the vehicle for the weekend, with one primary driver who never touched a radio, in hindsight we were very fortunate to have completed on the order of 1600 miles without incident! Over-the-road truckers are allowed only so many driving hours before they must take a break for a mandatory number of consecutive hours. These rules are in place to mitigate the number of accidents caused by driver fatigue. Rovering hams are no less at risk due to fatigue during or after a 33-hour contest. Just ask W3HMS after *his* VHF contest roving related accident in 2004. This rule and its current interpretation virtually eliminate the possibility of another high grid count run 'n' gun effort simply because suicide is not a good way to end a contest! This is a shame, because ND2X believes a 40-grid effort is possible.

Logging: Record-keeping during a contest, or *any* operation, basically is limited to two approaches. Either one uses pencil and paper, or one employs a computer-based logging program. ND2X lost a few thousand points in September 2000 because the logging program in use "blew up" after 31 grids activated, and some QSO records were lost. This shortfall has been corrected for the program used at that time, and there are myriad programs from which to choose; do an internet search ("VHF logging software," "ham radio logging software," "amateur radio logging software," etc.) and see! "You pays yer money and takes yer choice!"

Run 'n' gun rovers must find a means of logging while driving, navigating, operating, or whatever. This means either having two folks engaged at all times, or finding some means to record all pertinent data for after-action transcription. Shoot 'n' scoot rovers do not have this restriction when operating at a portable location. In either case, logging can be computer-based or paper and pencil. Much of the modern logging software keeps track of duplicates; automatically records time, date, and grid for each contact (GPS connection); and even produces after-action logs in Cabrillo format. Some also "automatically" e-mail results to the ARRL once reconnected to the internet after a contest! What a deal!

Station Configuration

Of prime concern is keeping any roving station installation as simple as possible. The "KISS" (Keep It Simple Stupid) principle cannot be overstated here! Complexity is merely an open invitation to Mr. Murphy. Ground loops, RF feedback, overdriving transverter inputs to the point where the smoke escapes, telescoping antenna masts not telescoping or not collapsing, rotators not rotating, and any number of other cataclysmic maladies *will* occur unless KISS is applied across the board. Integrating equipment, even such as using a simple switchbox to switch one headset among all radios, can rapidly become *over* integration because of the problems caused—in this example, ground loops and RF feedback. Backup or replacement parts and gear should also be considered. Extra microphones, headphones, AA batteries for the GPS, fuses, automotive light bulbs, coaxial cables cut to length with connectors installed, spare antennas and antenna parts, etc., can make a tremendous difference. Having spare equipment is a very effective Murphy preventative!

Equipment: The equipment suite chosen is another area driven by personal preference, although there are certain constants that apply to all stations. A GPS is invaluable for positioning information. Radio gear should be chosen to minimize the use of transverters, realizing transverters cannot be avoided for most bands above 2300 MHz, plus 902/3 MHz. A single "IF radio" used for all transverters is the best of all transverter worlds, but not always possible. Power amplifiers can be the difference between a successful rove and a frustrating effort filled with stations heard but not worked. Nothing will work, of course, without an adequate power source. Top off whatever approach chosen with a detailed checklist to be completed prior to departure, and the probability of success can be quite high!

GPS: A GPS receiver is a must if one is operating while on the move. Once one is committed to a specific route, a GPS receiver is the simplest, most accurate means of keeping track

Photo H. Some shoot 'n' scoot rovers use an antenna base that is secured to the ground by driving a vehicle's front tire onto it. The tower is bolted quickly to the pre-existing hinges and then tilted up from the base. The example shown is from KL7JR.

of one's location. Shoot 'n' scoot stations if operating while traveling between stops, and run 'n' gun stations, are always watching for that next grid. While it is possible to mark latitude and longitude on a paper map, it is clumsy and often inaccurate by as much as 400 yards. GPS is often accurate to less than 21 feet. ND2X uses Garmin GPS equipment because it can be set to read out location in six-digit maidenhead grid notation, but here again, "You pays yer money and you takes yer choice!"

Radio Gear: As with most aspects of ham radio, radio equipment selection is a budget-driven situation. ND2X sold an IC-706 mk II, an FT-847, and a pristine Drake TR-7 to gather the cash to buy a TS-2000X for the mobile—one radio, four VHF/UHF bands, plus a transverter mode with band-specific frequency readout to run 902 MHz. An IC-375A rounds out the 6-meter/23-cm installation. N4FLM uses an IC-746 modified for low-level output on 28 MHz to run 222- and 1296-MHz transverters, so one radio handles four of the five bands implemented. An FT-100D is used to cover 70 cm as well as to provide some backup. ND2X plans to add 2304-MHz through 10-GHz transverters using an FT-817 IF rig. The transverters will be placed remotely, as close to their antennas as possible; control and switching issues are sure to present a challenge. "KISS"?

There are a couple of mode-driven differences for equipment installation. For the run 'n' gun rover, or for any "mobile-in-motion" operation, equipment must be readily accessible with operators strapped into normal vehicle driver/passenger positions. If the driver is to operate at any time, radio, amplifier, and power controls applicable to operating while in motion must be within arm's reach and generally as high off the floor as possible to preclude the driver having to look down. Looking off a little to the right or left of straight ahead allows one to remain "road vigilant" with peripheral vision.

Shoot 'n' scoot rovers can have most or all equipment mounted at an operating position that is other than driver/passenger accessible—for example, an operating table in the back of a van, or the covered bed of a pickup truck, etc. *No matter what mode used, all equipment must be mounted securely.* Under

certain undesirable conditions, a loose piece of equipment can turn into a lethal(!) projectile. Some years ago, a car that had a box of facial tissues sitting loose on the flat area behind the back seat was involved in a frontal collision. The car and driver stopped, but the box of tissues didn't until it hit the driver in the back of the head, killing him instantly. It's easy to imagine how much more dangerous a flying radio would be to vehicle occupants.

Power Amplifiers: Since run 'n' gun rovers generally use omni-directional antennas with relatively low gain over a dipole, they need all the power available, at least up to 500 watts. Experience indicates that 500 watts is about the maximum level at which a mobile station using 4–5-dBd gain omni antennas can hear as well as be heard. More than 500 watts and the "average" fixed station will hear and call, but the rover may not hear him; fixed stations running full legal limit would be the exception.

Shoot 'n' scoot rovers make up for brute-force power, at least while stopped on a mountaintop, by using high-gain directional antennas. This doesn't mean shoot 'n' scoot folks should use QRP, by any stretch of the imagination! In fact, with directional antennas to provide several dB of gain on receive, the shoot 'n' scoot station could probably use at least 800 watts before becoming an "alligator" (all mouth, no ears).

Antenna Configuration: Antennas are the main difference between shoot 'n' scoot and run 'n' gun rovers. Whereas shoot 'n' scoot folks raise directional antennas at each stop, the run 'n' gun rover *never* touches an antenna unless a repair or replacement becomes necessary due to mechanical breakage. Mechanical breakage can come from unintentional interaction with low-hanging tree limbs, cable TV, and even power-line cables strung across roads below minimum height; bird strikes; and metal fatigue from the vibration caused by unloaded one-ton pickup truck suspensions. The run 'n' gun antenna configuration never changes.

Shoot 'n' scoot rovers use various methods to erect antennas. N4FLM has a nice mechanical crank-up tower mounted in the bed of his pickup truck which puts his top antenna at 30 feet or so. He avoids non-mechanical means to raise antennas–for example, pneumatic towers—to stay away from anything with seals; bad seals are almost sure to keep one from successfully raising the antennas at the most inconvenient time! KISS! Some use an antenna base that is secured to the ground by driving a vehicle's front tire onto it; the tower is bolted quickly to the pre-existing hinges and then tilted up from the base. The example shown in photo H is from KL7JR. These towers can also be telescoping, as in crankup. In extreme situations, such as the aforementioned winds atop Mt. Washington, these towers can be guyed or, more properly, roped off, by tying ropes from the tower top to nearby fence posts, trees, boulders, barrier or safety rails which prevent pedestrians from straying off the sidewalk, or whatever solid, immovable object is present.

Powering the Station: While run 'n' gun rovers never have to worry about running down batteries (since the engine is always running), shoot 'n' scoot folks are in a different situation, as they operate primarily while stationary. Shoot 'n' scoot rovers have the luxury of being able to turn their vehicle's engine off and use a generator to power their station at each operating location. Run 'n' gun rovers could run a trailer with a generator and power cable running to the prime mover with the station installation in it, but this level of complexity would definitely *not* be following KISS principles, and it has additional safety concerns which further complicate matters. Note that the common situation for any rover is that only one transmitter will be operating at any given time, limiting power requirements to a relatively reasonable level.

There are myriad practical means of powering a rover station. Some rovers power stations using completely stock, unmodified automotive electrical systems. Some rovers modify their electrical systems by installing an extra battery or batteries in their vehicle. This group most often uses standard off-the-shelf recreational-vehicle battery isolators to separate automotive and communication-system batteries, preventing radios from drawing off the automotive batteries. Some use inverters (there *are* some electrically quiet inverters out there) in conjunction with whatever 13.8-VDC automotive system is in use, and some use separate gas or diesel generators that are part of their rover equipment. At the risk of more redundancy (a little humor here), "You pays yer money and you takes yer choice!"

ND2X has operated without problems at 400 watts output on 2 meters from platforms as small as a 1992 Plymouth Acclaim, sporting its whopping 90-amp stock alternator and single battery. The next platform, a '95 Ford F-350 diesel, used the stock 130-amp alternator and the dual batteries present; no problem. The current platform sports two 130-amp alternators, one of which was completely removed from the automotive electrical system and rewired to charge a separate battery installed in the bed of the pickup truck. This is dedicated to powering the antenna hydraulic system and the power amplifiers. It may, one day (it's good to dream, right?), power a 1.8-KVA sinusoidal inverter dedicated to tube amplifiers for that magical 500 watts output on all bands through 23 cm! (Note: The second alternator and battery system was not created because it was required; it was done because it was possible!)

N4FLM uses a 3-KW Honda generator to power all of his equipment. He never has to worry that he might run his automotive battery down and become stranded because he cannot start his vehicle. He must, instead, track the amount of fuel available for the generator.

Summary

In planning for your rover operation, keep in mind the following eight important points:

1. Safety First!
2. "KISS" (Keep It Simple Stupid)!
3. "You pays yer money and you takes yer choice!"
4. Ultimately, everything is driven by personal preference and budget.
5. There are two primary modes of roving. Using military parlance, one is labeled "shoot 'n' scoot" and the other is termed "run 'n' gun."
6. The mode of roving employed is determined by terrain, vegetation, existing roads, infrastructure and traffic, population density and distribution, climate and weather, and area-specific propagation.
7. The four main functions involved in roving are driving, navigating, operating, and logging. Note which is most important (see #1, above).
8. Have fun! ■

By Del Schier,* K1UHF

AIRBORNE RADIO

Using Amateur Radio to Control Model Aircraft

An Introduction to Using Amateur Radio to Control Model Aircraft

Amateur radio has many facets, possibly too many to explore in a lifetime. This column will discuss one aspect—radio control, or RC. This new "Airborne Radio" column will give a general overview of radio control, for which hams are licensed to operate on 6 meters. I will be sharing with you this interesting and enjoyable segment of amateur radio, and I hope that this new *CQ VHF* column will be of interest to all radio hobbyists.

Many amateur radio operators have similar interests within and outside our hobby. I have met many hams on the air who are "full-scale" or RC pilots. I also meet a good number of hams at RC model events. RC modeling by itself has perhaps as many facets as amateur radio and shares many similar aspects.

RC modelers who are licensed hams use 50 MHz to control their model airplanes. Amateur television and telemetry experimenting takes place on the 432-MHz amateur band. The two hobbies are not only similar, they are also intertwined.

Identical twin brothers, Walt Good, W3NPS, and Bill Good, W8IFD (later W2CVI), made the first RC flights in 1936. Historians credit them with being the first hobbyists and radio amateurs to

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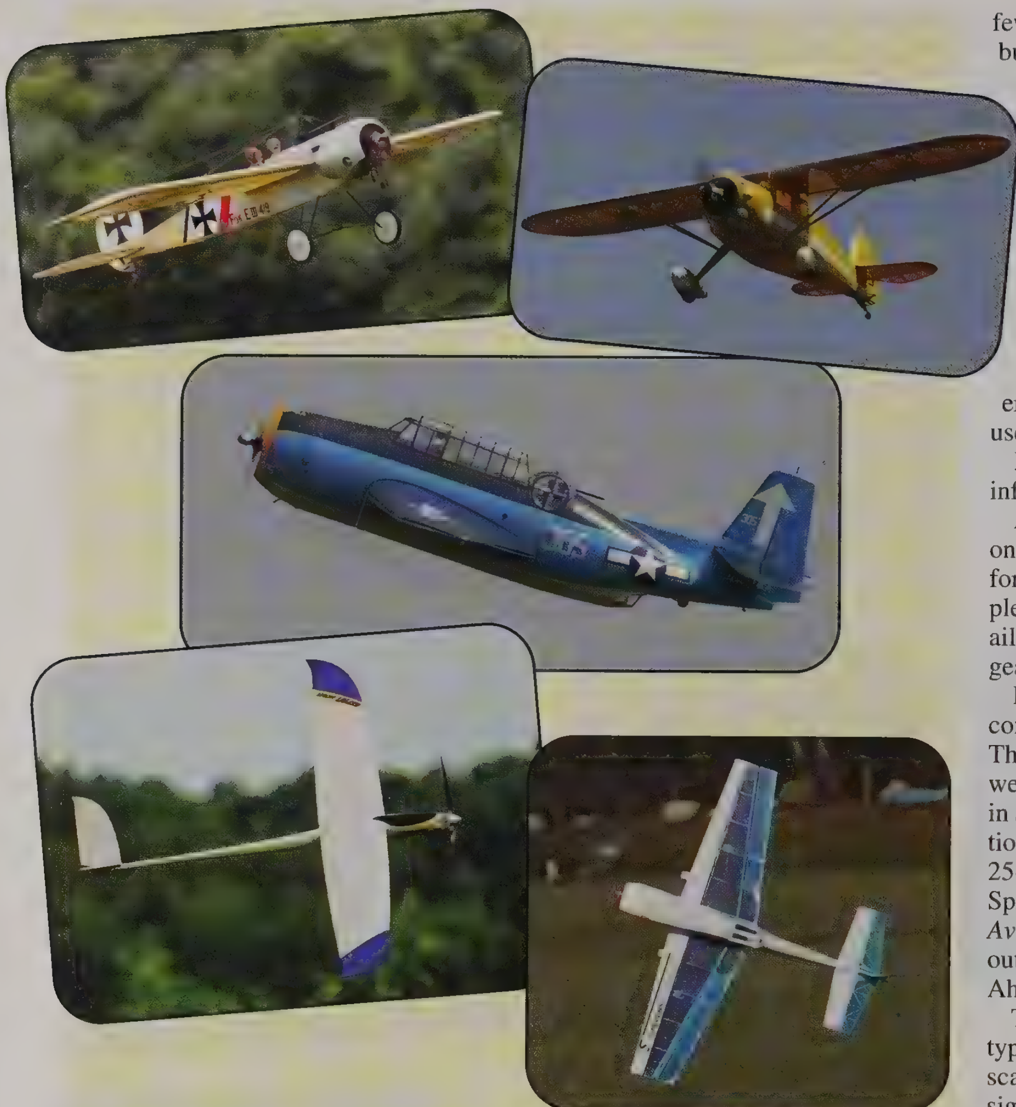
Some examples of the variety of model aircraft: balsa, foam, carbon fiber, scale, indoor, 200 mph—you name it! (All photos courtesy of Walter Sidas, FlyRC Magazine *<www.flyrc.com>)*



More examples of the variety of model aircraft.

fly RC in the United States, and perhaps the entire world.

The Winter 2004 issue of *CQ VHF* had an article on the historic RC model flight ("A 6-meter Rig Flies the Atlantic," by Maynard Hill, W3FQF), where on August 11, 2003 an RC model flew non-stop, unrefueled, across the Atlantic Ocean! It was controlled on 6 meters with a 432-MHz beacon and was built by a team of volunteers led by W3FQF.

Analogies may be made between both hobbies. Airfoil design and antenna design, both with highly evolved engineering disciplines, both require almost a sixth sense and a great deal of experience to come up with effective designs. Piloting an RC glider that is dependent on Mother Nature's thermal updrafts is as fascinating as observing the variations in radio propagation.

In this column I primarily will discuss electric-powered RC aircraft. Wet-fuel-powered aircraft are still popular, but the trend is toward quiet and clean electric power. Electric flight, involving more electronics, is what I suspect most hams would be interested in. Recent technology, including Lithium Polymer batteries and three-phase brushless motors, have made electric-powered model aircraft match or exceed the performance of fuel-powered models, and in my opinion this is the "way to fly." Personally, I also enjoy flying pure gliders powered only by the sun's energy.

Like ham radio, there are no longer many dedicated home brewers. There are few kits and not as many kit or scratch builders as there used to be. Today the majority of model aircraft are supplied Almost-Ready-to-Fly ("ARF" for short). ARFs come almost completely built, usually to the extent that the airplane can still be packed in a shipping carton. Getting an ARF model ready to fly most often involves only attaching the wing and the tail to the fuselage and installing the radio, servos, and motor system. Today it is much easier to get a model airplane flying than it used to be, but perhaps not as satisfying.

For starters let me give you some basic information about RC model aircraft.

An airplane can be very simple, with only two servos, one for elevator and one for rudder. Of course, it could have a complete set of controls, including flaps, ailerons, spoilers, retractable landing gear, and more.

Model aircraft come in almost every conceivable size and shape and type. There are micro-flight RC models that weight only a few grams can fly around in a living room. With special authorization, you can actually fly a 400-pound, 25-foot-wingspan electric-powered Spruce Goose, as was built for the movie *Aviator*. The Spruce Goose used eight outer rotor brushless motors with 20 3.3-Ah NiMh batteries for each motor!

There are scale models of almost every type of airplane, with varying degrees of scale accuracy. Many models are designed only for a specific realm of flight and may have been designed without any concern for realistic scale appearance. For example, a sailplane may be totally optimized for maximum aerodynamic efficiency and not include landing gear or a cockpit for a scale pilot. So-called "3D" aerobatic airplanes are made for one purpose: outrageous aerobatic flight that a real stunt plane could not perform. You will find all types of aircraft: flying wings, biplanes, triplanes, canards, gyrocopters, parasails, helicopters, ornothopters … you name it.

Some model aircraft are still made from balsa wood, but many are not. There is a trend toward great flying and inexpensive cut- or molded-foam construction. The more exotic aircraft use fiberglass, carbon fiber, Kevlar®, and other composite materials.

A model may be powered by one or more motors or may be a pure glider without anything but Mother Nature's updrafts. Electric motors range from tiny

Transmitters for 6 meters are avialable from several manufacturers.

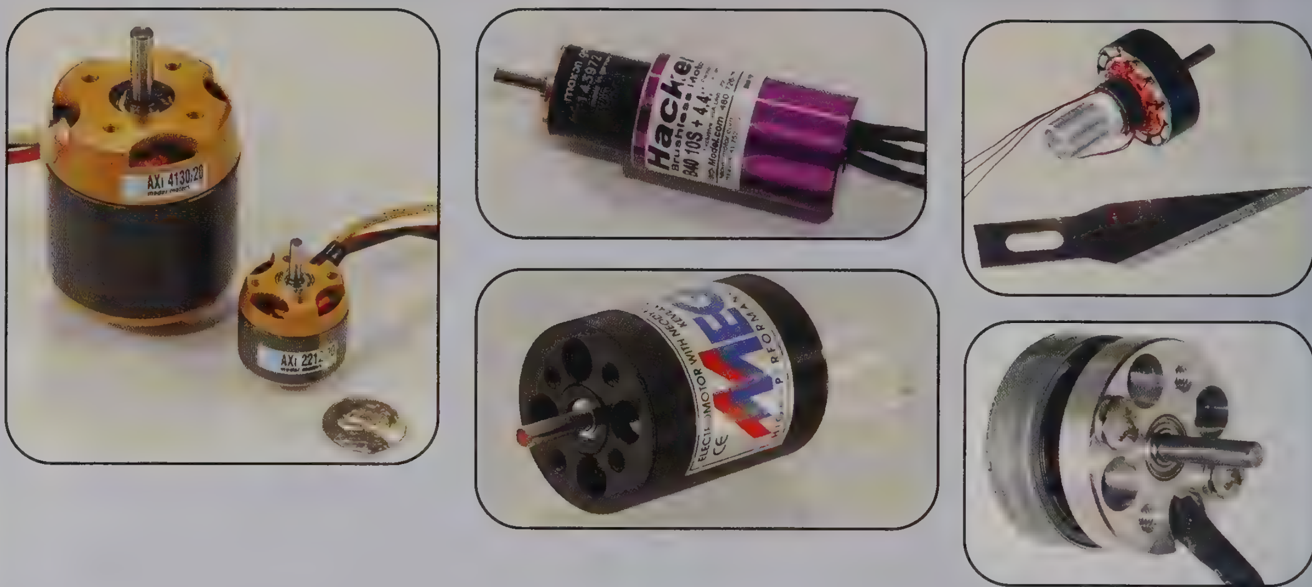
Receivers for 6 meters, even synthesized, are available in many sizes.

Servos range from incredibly small to large, powerful ones.

cell-phone/pager vibrator motors and $5 DC cordless drill motors, all the way to super-efficient three-phase AC brushless motors developed especially for RC aircraft. Fuel-powered airplanes may use gasoline spark engines, glow-plug or diesel-ignited methanol/nitro methane power, or even kerosene-burning model turbine engines.

Electric motors are "fueled" by NiCad, NiMh or Lithium Polymer (LiPo) batteries. LiPo batteries are a recent development that represents a tremendous improvement in flight performance with one third the weight of the same capacity NiCad pack. A medium-size electric model may draw 60 amps from an 11-volt 4-Ah LiPo battery pack. Electric-power systems range from a fraction of a watt to over 2500 watts. Brushless motors have efficiencies of well over 90% with a one-horsepower motor weighing a few ounces and only a bit bigger than a 35-mm film canister.

Electric motors are controlled via the throttle channel of the receiver using sophisticated electronic speed controls (ESC). An ESC uses switching FETs to



Three-phase brushless motors are now the most popular and come in all sizes, up to 3 horsepower.

govern the motor's speed either by varying the pulse width for a DC motor or by generating a three-phase AC signal for a brushless motor. An ESC usually will include a regulator circuit to bring the motor battery down to 5 volts to run the airborne receiver and servos without the need for a second flight battery. These regulated outputs are called BECs, or Battery Eliminator Circuits.

The motor's power is fed to a propeller either directly or with gear reduction. Small motors may run at more than 40,000 RPM, so the use of a gearbox allows for a larger diameter, more aerodynamically efficient propeller. A propeller must be chosen to load the motor system in a safe power range, and the entire package must be suited to the airplane's weight and flying speeds. Model jets will sometimes be propelled with an internally mounted ducted fan or actually use a model turbine engine. A recent development of in-flight variable pitch, reversible propellers makes for some very interesting aerobatic capabilities.

Radio systems are usually purchased as a package of transmitter, receiver, and servos and can range from two channels to fourteen. Good-quality radio systems provide proportional control of each channel and use various modulation schemes. The most common are FM transmission with PPM (Pulse Position Modulation). Until recently, transmitters and receivers were crystal controlled, but now synthesized frequency selection is available. Auto-adapting, non-interference, spread-spectrum transmission is on the horizon.

Frequency conflicts are a real concern with RC modeling. Most flying fields have strict procedures to ensure that no one transmits on another modeler's frequency, causing loss of control of one or more airplanes. Ham RC modelers have a nice advantage on 6 meters, as they do not usually have to wait their turn, as most other modelers are on 72 MHz. While we are on the subject of interference, it is interesting to note that RC is also threatened by BPL (Broadband over Power Lines).

In my next column I plan to cover how to get started in RC modeling. Future columns will touch on various aspects of the hobby, such as aircraft, motors, radios, control systems, batteries, video, and the like.

73 and happy flying!

Del, K1UHF

Real-life Dynamic Range of Modern Amateur Transceivers

Reprinted from *DUBUS** magazine, this article deals with the correct way to measure transceiver quality.

By Leif Åsbrink,† SM5BSZ

Following the recent general advances in receiver design, the receiver part of a typical amateur transceiver now has quite good ability to handle strong, unwanted signals—but only if those signals are free from unwanted spurious sidebands (notably keyclicks, splatter, and other transients). In contrast, the transmitters have been almost completely neglected. This article gives measured data for several different transceivers from different manufacturers, and it shows that the transmitters are becoming the most important source of inter-station interference. A major contribution to unwanted sidebands comes from ill-designed ALC circuits. The article also discusses what we can do to avoid generating interference to one another, by controlling the output power by means other than the internal ALC.

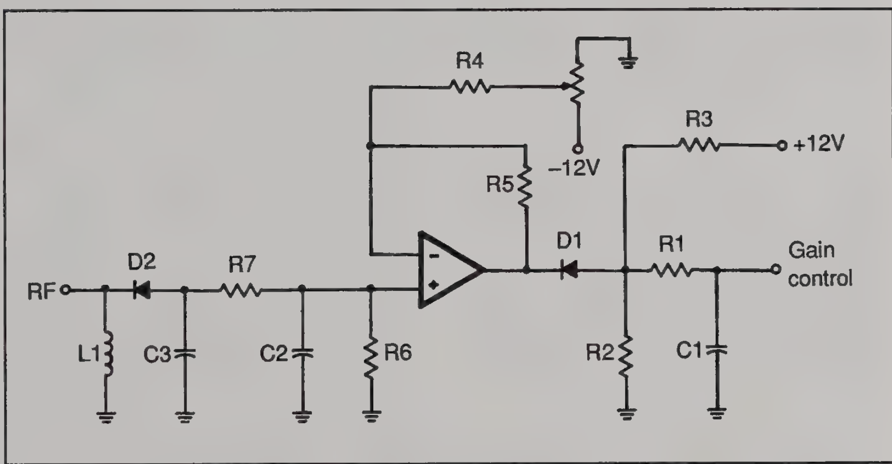


Figure 1. Simplified ALC schematic.

Introduction

Inter-station interference can occur when a receiver is trying to listen on a clear frequency, but there is a very strong transmitter using a frequency close by. All transmitters have unwanted sideband emissions (keyclicks, splatter, and other transients—the type depends on the transmission mode). If the suppression of these sidebands is worse than the dynamic range of the receiver, then the transmitter will be mostly responsible for the interference experienced by the receiver. Modern amateur receivers have quite good dynamic range, on the order of 90 to 100 dB with the usual definitions (500-Hz bandwidth, and at frequency separations beyond a few kHz). To avoid causing interference to such receivers, the unwanted sidebands from our transmitters must be suppressed to better than –120 dBc/Hz on the frequency to which the receiver is attempting to listen.

Previous articles have dealt with unwanted sidebands due to keyclicks on CW, and splatter on SSB, and have shown that major improvements are needed.[1, 2, 3] The measurements uncovered a significant source of unwanted sidebands that are added by ill-designed ALC circuits. This article explores further, focusing mainly on the effects of poor ALC on the bandwidths of SSB and CW transmissions, and gives actual measured data for several different transceivers from different manufacturers.

Speech Processing and ALC

All voice-modulation methods have an amplitude limit, a level that must not be exceeded. This is valid for FM and SSB as well as for AM. It is, of course, possible to set the microphone gain low enough to make the largest amplitude peaks that occur when speaking into the microphone so low that they will never exceed the limit. Doing so will provide the best sound quality, but only when the RF signal is strong. The average amplitude from the microphone would be far below the limit nearly all the time, and the transmission channel would be poorly used.

As amateurs, we usually are not very interested in high fidelity in the repro-

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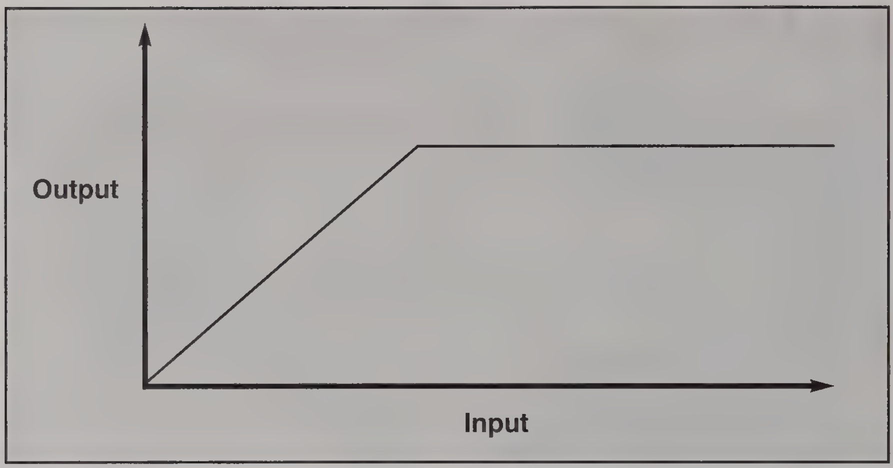

Figure 2. ALC is a form of amplitude limiting.

duction of our voice in the loudspeaker of our QSO partner. What we want is the best possible intelligibility, at low RF signal levels and also in the presence of interference. To this end we use speech processors, one way or another. All amateur transmitters contain speech processors of some kind, even though the user may not be aware of it because the circuitry may have a different label.

Speech processing usually means amplitude clipping. This is a simple way of making sure that the amplitude does not go above some specified limit. However, clipping will change the frequency content of the signal, and therefore a clipper needs to be followed by a filter to remove signal components outside the intended bandwidth. This is all very well known and written about in the literature. Unfortunately, the manufacturers of amateur transceivers do not follow this simple rule about filtering. When they use ALC to control the maximum amplitude of the RF envelope waveform, they change the shape of the waveform but there is no filter that removes the signal components that are generated out-of-channel. Modern ALC systems have high gain and large bandwidths, and they flatten the envelope waveform abruptly, which leads to wideband interference. This means that even the emissions from transceivers used at reduced power are far from acceptable. For example, on 144 MHz the FT-817 even has problems complying with the FCC emission rules §97.307(e), which generously allow spurious emissions with a mean power up to –43 dB with respect to the mean power of the fundamental emission at a power level of 0.5 watt. The problem is common, and by no means limited to the FT-817 or to Yaesu as a manufacturer. Also, the problem is by no means new, but it has worsened over the years.

Fortunately, it often is possible to use a properly designed speech processor, limiting the amplitude of the RF drive signal so that the ALC is not activated. Many transmitters already contain a separate speech processor, so in the IC-7800 and FT-1000D, for example, it is possible to set the controls so that the peak envelope power reaches the desired level without activating the ALC at all. The desired level then is only a few tenths of a dB below the level that would have been set by the ALC, but the transmission is a lot cleaner. Other transceivers such as the Orion cause a lot of needless interference

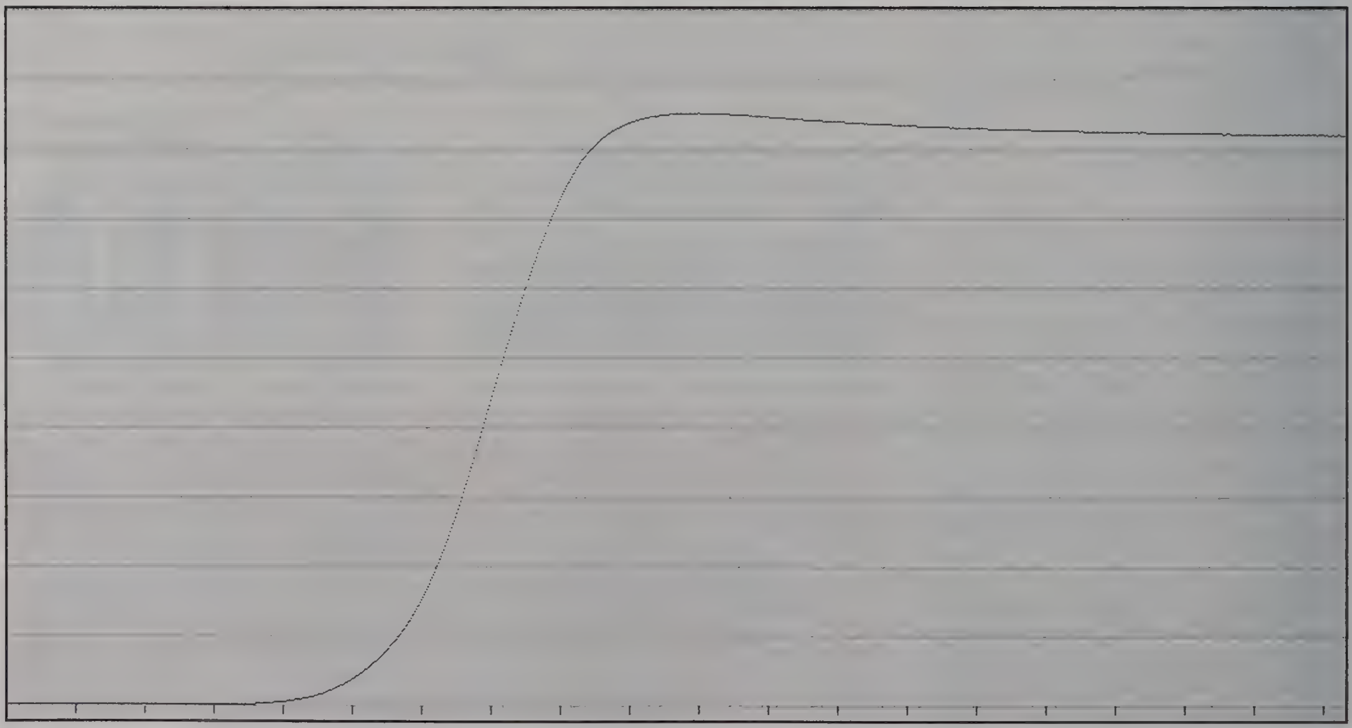

Figure 3. First key-down transition of a TS-2000 on 144 MHz. A rare example of a transceiver in which the ALC does not cause spectral broadening.

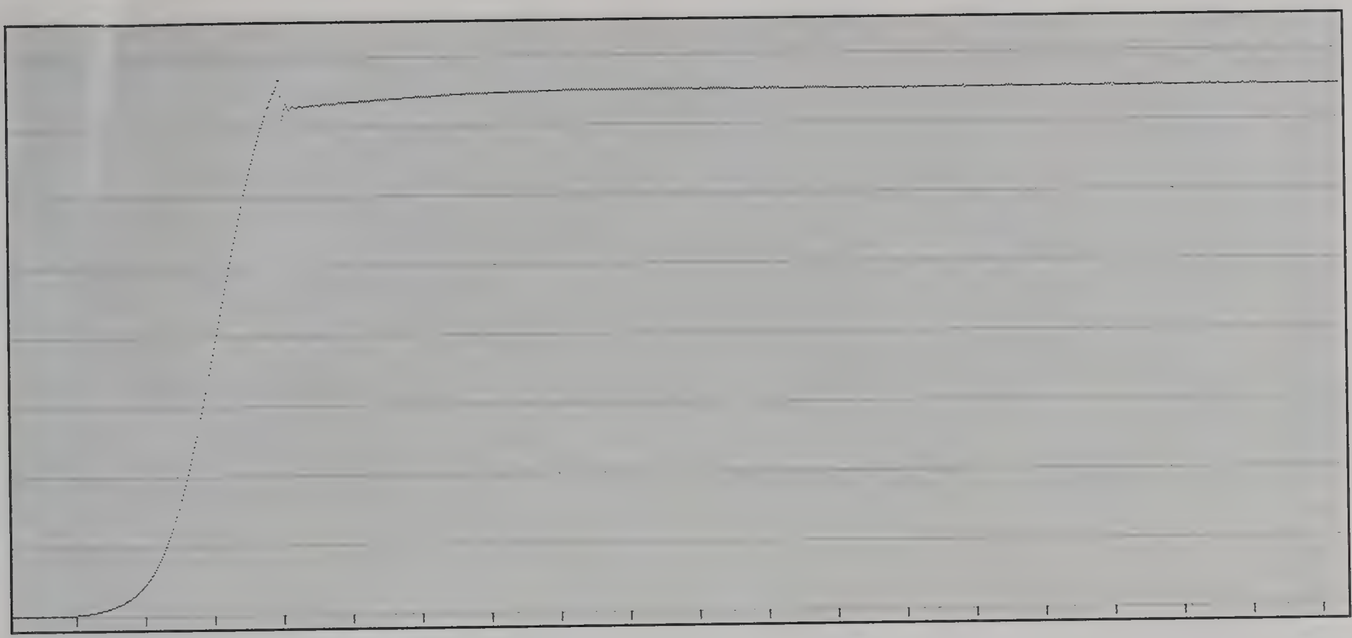

Figure 4. First key-down transition of a Ten-Tec Orion on 14 MHz. Note the ALC transient at the top corner.

that could easily be removed by a software update; the computer inside has full control of everything, but the transmitter RF gain does not have a front-panel control. Another possibility is to control the transmitter RF gain by feeding a variable negative voltage into the transceiver's "External ALC" input, which overrides the internal ALC. Often it is easy to make a modification to use the FM speech processor in SSB mode[2]; this was published over 20 years ago.

Besides generating out-of-channel interference, the ALC systems of modern transceivers make them generate occasional pulses of very high power—far above the maximum rated output of the transceiver. These pulses may cause damage to equipment, may cause protection circuits to operate, or at the very least may cause key-clicks and splatter. The problem is not limited to SSB mode. A wideband pulse is generated in any mode every time the ALC has to turn down the gain quickly, and that happens each time the power has been low for a time that is longer than the ALC decay time. For some transmitters it happens after each word space in CW, while for others even after every space in a string of dots at high speed. There is a particular danger for transverters and other equipment that can only accept a low RF power input; if the power output of the transceiver is reduced simply by turning down the RF PWR control, the transceiver's ALC may still allow pulses of very high RF power. These may either destroy semiconductor devices or cause a gradual worsening in performance.

The ALC System

The ALC system is a simple servo system, and the theory should be well understood by every electronics engineer. The reason for the poor performance is that product testing in amateur journals does not look for the out-of-channel emissions of modulated transmitters, except for the two-tone test, which is a static test as far as ALC is concerned. The maximum power level repeats at typically 1-ms intervals in a two-tone test, and therefore even a very short ALC decay time is long enough to keep the ALC voltage nearly constant.

The principle of an ALC system is illustrated in figure 1. The output signal is coupled through a directional coupler to the RF input at the left side of figure 1. Diode D2 rectifies the RF signal and charges C3 to the peak value of the RF voltage in the negative direction (minus the diode forward voltage). The low-pass link R7-C2 removes remaining RF components and feeds the negative peak RF voltage to the positive input of the op-amp. If the RF power is well below the power limit, which is set by the potentiometer, the op-amp will saturate in the positive direction and the gain-control output will have the voltage defined by the voltage divider R2 and R3.

As the RF power increases, the rectified voltage will go further in the negative direction until the output voltage of the op-amp goes below the gain control voltage by the forward voltage drop of D1. Then D1 will start to conduct and reduce the RF gain so the RF power will no longer increase, but will stay at the level set by the potentiometer. The transmitter gain can be reduced rapidly (fast attack), but with a large value for R6 it will increase slowly (slow decay).

It is pretty obvious that an ALC system such as this will behave nicely if the response time for gain reduction is much faster than the envelope rise time of the RF signal sent into the transmitter. A less obvious second condition for good behavior is that the phase shift in the servo loop formed by the RF circuits and the ALC system must remain below 90 degrees at all frequencies where the loop gain is above 1. With a slowly rising signal level, the output power will be proportional to the input power (the power that comes out from the bandwidth-defining filter) up to the limit level, where there is a knee, after which the input power may be increased but the output power increases very little. Thus, the transfer curve is essentially two straight lines (figure 2), and for practical purposes the upper line can be taken as horizontal. For slowly varying signals, the ALC behaves exactly like an amplitude limiter in the way it affects the envelope shape, and for such signals it therefore generates inter-

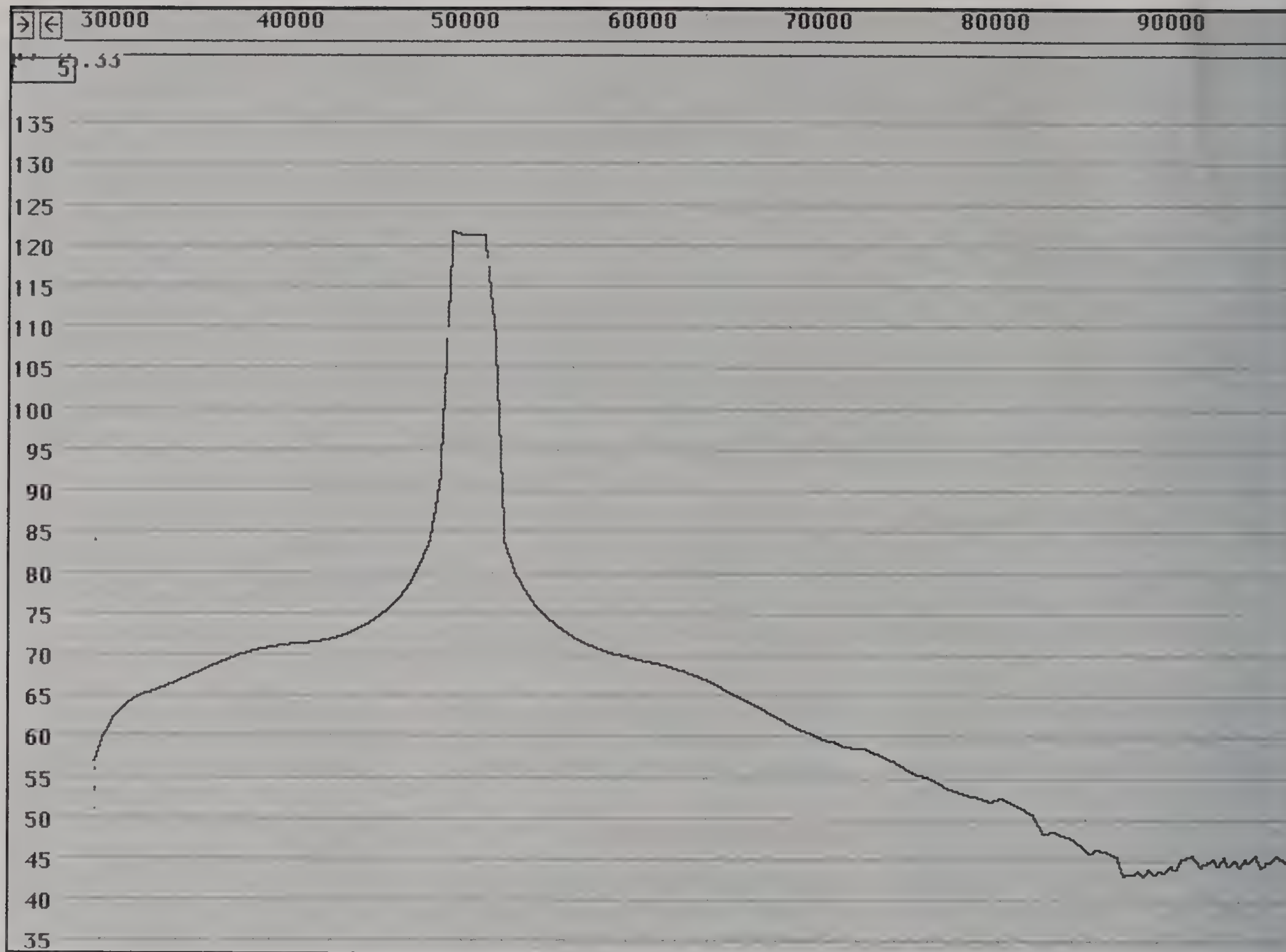

Figure 5. First key-down transition of a Ten-Tec Orion on 14 MHz. This is the peak-hold spectrum in 2-kHz bandwidth from the same Orion producing the waveform of figure 4. Because of the ALC transient, the keying clicks are only about 20 dB below those of a transmitter with totally unfiltered cathode keying!

modulation exactly like an amplitude clipper does.

If the attack time constant is made very short in relation to the rise time of the SSB or CW envelope waveform, there will be a transient at the knee point where the ALC system starts to reduce the gain. Such a transient is a splatter pulse or a keying click, and its magnitude depends on how much the gain has to be reduced. By having a very long release time constant one can ensure that the amount by which the gain needs to be lowered next time is very small. This way there will only be one interference pulse at the onset of each transmission.

If the attack time is made a little longer, for example by increasing R7, there will be an overshoot at the onset each time the ALC becomes active. If gain levels are set so that the ALC only ever needs to reduce the transmitter gain by a small amount, one can select a rather long attack time, which will generate a nicely rounded overshoot that does not increase the bandwidth. Such an overshoot is completely harmless if the transmitter is connected to an antenna, but if it is used with a power amplifier it could drive the power amplifier into saturation, with a very strong interference pulse as a consequence. It could also be harmful to the amplifier, or activate a protection circuit which takes the amplifier off-line. Figure 3 shows the first key-down transition of a TS-2000 on 144 MHz at full power (100 watts). This is one (rare) example of a correctly working ALC circuit.

If the loop gain is too high, the amplifiers within the servo loop saturate and the servo system becomes non-linear. Then transients of large bandwidth may be emitted, and also the loop will over-react, bringing the gain down too much. The

CW Setting	Carrier peak (W)	SSB continuous (W)	PTT-off peak (W)	peak (W)
H	75	49	108	120
5	55	33.8	78	116
2	16.4	9.5	32.4	97
1	10.0	5.0	11.3	79
L	5.2	2.5	9.0	46

Table 1. Power output transient levels at the antenna connector for an IC-706MKIIG.

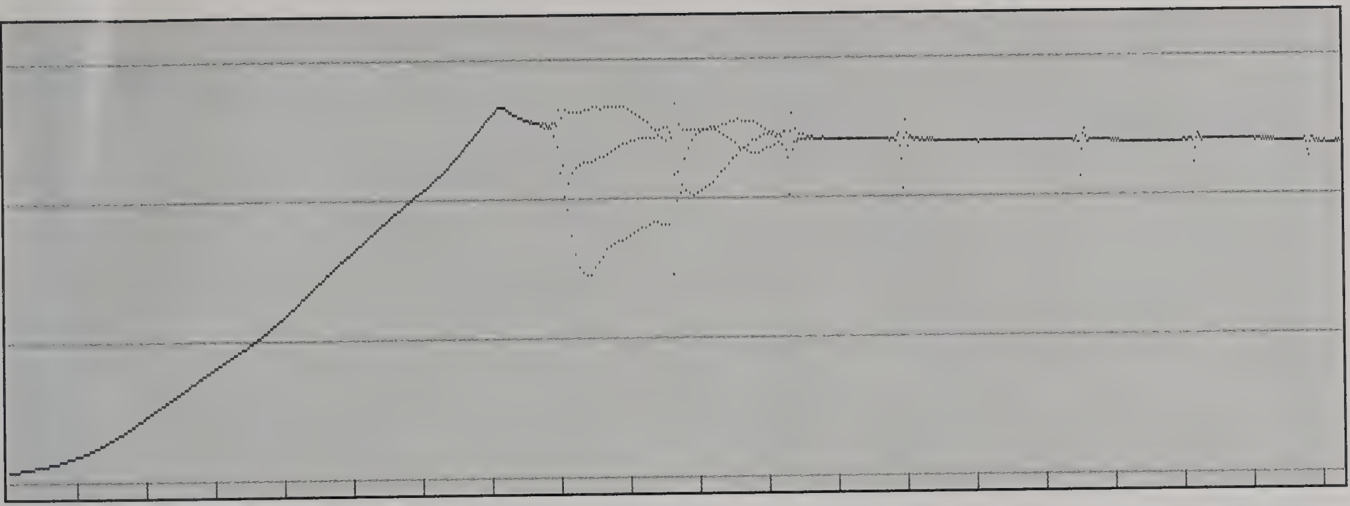

Figure 6. First key-down transition of an FT-817, 14 MHz. Note the self-oscillation in the ALC circuit.

slow ALC release time constant (R6*C2 in figure 1) will then slowly allow the power to reach the desired level again. Figure 4 shows the first key-down transition on a Ten-Tec Orion, which is an example of this phenomenon. The designer clearly intended to give a nice "raised-cosine" or S-shape to the rising edge to minimize key-clicks, but the top corner is severely distorted by the ALC transient and the resulting spectrum in figure 5 is far from what one would have hoped.

Unfortunately, most amateur transceivers are no better designed. The gain in the servo loop is often very high and the phase shift large, with stability problems as a consequence. It is a general rule in the design of servo loops that one should not have more than one RC link to set the gain vs. frequency function for the loop. If R7*C2 and R1*C1 are made with similar time constants, the servo loop is close to an oscillator, and more delay through more RC links makes it even worse. It is a good idea to make all RC links except one with time constants that are at least 100 times shorter than the single large one that sets the loop gain roll-off with frequency.

Manufacturers of amateur transceivers seem to be unaware of this well-known rule about having a single "dominant pole." For example, figure 6 shows the waveform of the first key-down transition of an FT-817 on 14 MHz. The ALC is self-oscillating at a frequency of about 35 kHz, which produces the wideband transients measured in figure 7.

In better transceivers the front-panel "RF Power" control is simply a manual gain control which makes a fixed change in the RF drive level. However, many transceivers use the ALC system to implement the gain reduction dynamically, which means that the gain reduction that the ALC has to provide is larger at low power levels. This in turn means that the gain of the ALC servo loop becomes higher at reduced power, so oscillations may occur. Figures 6 and 7 show typical test results for the FT-817. The IC-706MKIIG behaves in a similar way, although oscillation is lower in frequency (about 5 kHz) amplitude and duration compared to the FT-817. The FT-817 is not even stable in the steady state when the key is held down, as can be seen in both figure 6 and figure 7.

As mentioned above, the use of ALC for regulating the output power may have other side effects. Table 1 shows measured power levels from an IC-706MKIIG at various power settings. The pulse emitted when the PTT button is released in SSB mode may be fatal for a solid-state power amplifier. [4]

Effect on Inter-Station Interference

There are two possible causes of inter-station interference on the air—receiver overload or transients from transmitters—and it is sometimes difficult to tell which is responsible. Receiver overload has been extensively reviewed, but transmitted transients have not.

State of the art in amateur transmitters is illustrated in Table 2, which shows the results of many measurements of peak hold spectra in a bandwidth of 2.4 kHz. The first entry of Table 2 shows the dynamic range of a typical receiver, an IC-706MKIIG, on 144 MHz. If any of the transmitter performance figures in the rest of the table is *smaller* than the receiver dynamic-range figure at the head of each column, it means that the transmitter, rather than receiver overload, would be the dominant cause of inter-station interference. Any transmitter performance figures that are equal to or better than this criterion are shown in bold, and you can see there are very few of them! Note the dramatic improvement in the IC-718 and IC-7800 that was achieved by disabling the ALC as discussed above.

The receiver dynamic range of the IC-706MKIIG is not especially good (for example, the TM-255E is about 20 dB better in dynamic range), so it is not a very demanding standard for comparison. Even so, most transmitters in Table 2 failed to meet that standard, which shows how poor is the typical performance of today's transmitters. There is no good reason for this, because it should be much easier to make a good transmitter than to make a good receiver.

The problem, of course, is that they all use the ALC to limit the RF envelope waveform. At narrow frequency separations the linearity of the final amplifier may affect the transmitter bandwidth, but above 15 kHz the interference mainly originates in the transmitter's ALC loop. To use ALC to limit the envelope waveform of a signal that has already gone through a speech processor is ridiculous, as discussed earlier, but very common in amateur equipment. ALC might perhaps have been a clever way of controlling the power level in the vacuum-tube era, but

Model	Power or ALC	Serial No.	Band (MHz)	Splatter Level Below PEP at 5 kHz (dB)	10 kHz (dB)	15 kHz (dB)	20 kHz (dB)	30 kHz (dB)	40 kHz (dB)	50 kHz (dB)
Typical RX (IC-706MKIIG)			**144**	**56**	**61**	**66**	**70**	**74**	**77**	**79**
DX70TH		T005735	14	15	15	32	32	51	55	68
DX77		T002056	14	31	50	51	51	51	59	68
FT-1000D		3G3300126	14	39	59	**66**	66	**75**	**77**	**79**
FT-1000MP MkV		4D570081	14	33	35	35	46	46	59	66
FT-736R		9E260294	144	31	50	55	59	67	74	**81**
FT-817	0.5W	1E270433	14	15	15	15	15	15	29	29
FT-817	0.5W	1D240059	14	13	13	13	13	13	27	27
FT-817	0.5W	1E270433	144	20	20	20	20	31	31	40
FT-817	0.5W	1D240059	144	15	15	15	15	32	32	32
FT-817	5W	1E270433	14	13	13	13	13	13	26	26
FT-817	5W	1E270433	144	40	49	49	49	61	61	75
FT-817	5W	1D240059	144	36	44	44	44	56	56	67
FT-847	2W	81100231	144	19	19	19	38	38	41	41
FT-847	low	81100231	14	18	18	18	18	35	40	40
FT-847		81100231	14	27	27	27	34	42	50	54
FT-857		3J130041	144	30	50	54	60	69	75	**79**
FT-857D		4D200054	144	33	52	60	66	71	**79**	**84**
FT-897			14	34	52	**68**	**74**	**80**	**80**	**82**
IC-706MKIIG		06230	144	28	48	58	62	**75**	**81**	**84**
IC-718	alc ON	03011151	14	41	52	56	58	61	62	63
IC-718	alc OFF	03011151	14	49	58	**69**	**75**	**84**	**84**	**85**
IC-765 40W		02576	14	36	52	59	64	64	64	64
IC-765		02576	14	34	37	37	37	37	37	37
IC-7800	alc ON	0301012	14	38	46	54	61	71	**81**	**88**
IC-7800	alc OFF	0301012	14	43	**68**	**88**	**88**	**89**	**89**	**89**
IC-910H		01533	144	32	53	64	68	69	69	69
Orion		03C10433	14	37	41	46	47	53	58	64
TR-9130		3040284	144	33	42	50	56	67	75	**82**
TS-2000		30400028	144	44	53	63	**76**	**85**	**88**	**89**
TS-2000		50600050	144	32	48	55	61	71	**86**	**89**
TS-2000	25W	50600050	144	35	48	64	**79**	**84**	**86**	**89**
TS-2000		30400028	14	31	45	57	66	**74**	**75**	**75**
TS-2000		50600050	14	32	53	59	68	**77**	**78**	**78**
TS-2000	25W	50600050	14	32	49	61	69	**79**	**79**	**79**
TS-50		41000988	14	50	**67**	**77**	**82**	**85**	**85**	**85**
TS-711E		8070268	144	17	27	32	42	53	58	67

Table 2. Peak-hold spectra of some amateur transceivers in SSB mode. With the exception of the cases shown in bold, the transmitted signal quality is likely to be the dominant cause of inter-station interference.

this aspect of transmitter design has stood still for 30 years. With appropriate knowledge about what the service menu functions do, or with a software update, most modern rigs can probably be run without the ALC as a speech processor. The computer inside a modern rig should be able to set the gain correctly for the constant amplitude signal that comes out from the SSB filter when a speech processor is used.

Speech Processing

Although best readability in SSB mode is obtained without speech processing, the peak power may then go as high as 100 times the average power, and practical transmitters cannot deliver such extreme power levels. In reality, there always is some engineering or legal limit on the peak power, and therefore, as pointed out in the introduction to this article, speech processing is necessary for optimum intelligibility in voice communication. (Saving energy when operating from a battery is a very special case. With cleverly managed bias currents, a battery-operated SSB station would be best used *without* speech processing for maximum battery life, but for the rest of this article it is assumed that transmitters are limited by peak power and that the total energy consumption is of no concern.)

It is well known from amateur literature that an RF clipper is much better than an audio clipper. This is not quite true, however: The RF clipper is better, but the difference is small as long as the clipping is not harder than necessary for optimum intelligibility. The drawback of audio clipping is often illustrated something like this:

Let us assume that the passband is 0.2 to 2.4 kHz, and that the signal from the microphone is 300 Hz at a given moment. An audio clipper will convert the waveform towards a square-wave that contains odd harmonics. The frequencies 900 Hz, 1.5 kHz, and 2.1 kHz will fall within the audio passband and make the sound very different from the original sine-wave. An RF clipper will, of course, also convert the sine-wave which is present at, e.g., 10.7 MHz to a square-wave. However, the

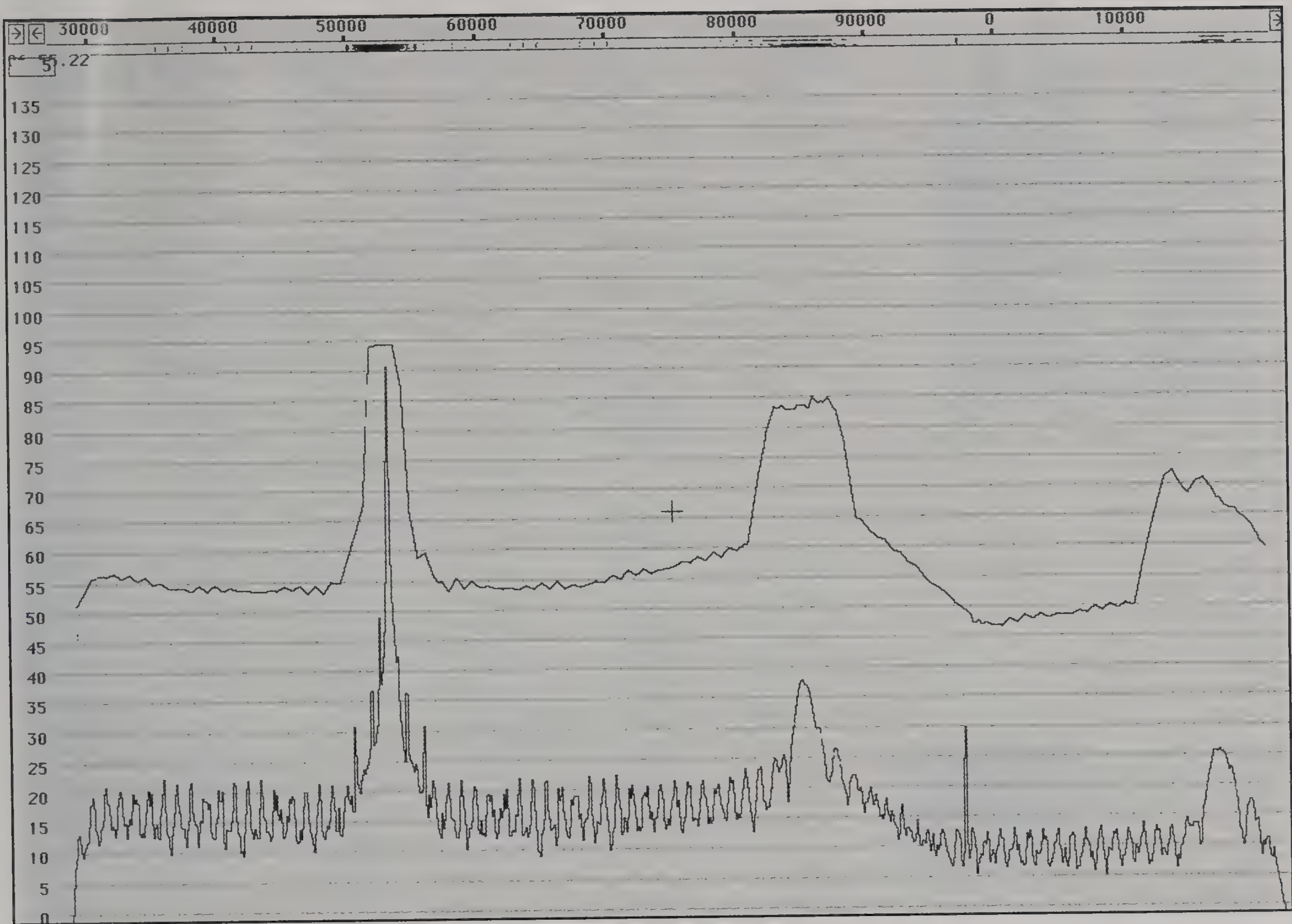

Figure 7. Spectrum corresponding to figure 6. This is typical of FT-817 when run at reduced power on 14 MHz. The upper curve is peak-hold in a bandwidth of 2.4 kHz and the lower curve is the average power spectrum at narrow bandwidth.

overtones at 32.1 MHz and higher will not pass through the filters, so only the original sine-wave will remain and be transmitted, and thus the output from the loudspeaker at the receive side will be exactly the original sine-wave (assuming a correct BFO setting). The only effect of RF clipping to a sine-wave is to reduce the amplitude to make it fit the power limitations of the power amplifier.

That line of argument that a sine-wave will not be distorted by an RF clipper may sound convincing, but it is not really valid. The very purpose of the speech processor is to change—to distort—the voice waveform. Indeed, if it fails to distort the waveform, the speech processor is not doing anything! The relevant question is whether the distortion to a voice signal that an RF clipper introduces is more favorable for intelligibility than the distortion produced by an audio clipper.

The human voice is not a sine-wave. If it were, an audio AGC would be the perfect speech processing, fully equivalent to RF clipping. With short pulses sent into the microphone it does not make much difference whether clipping is made at AF or RF. Likewise, if two signals at, say, 800 and 900 Hz were sent into the microphone input, the third-order intermodulation at 700 and 1000 Hz would be the same for RF and audio clipping.

One could argue that the human voice is much more like a series of pulses than a sine-wave, and that the difference between AF and RF clipping is small. The only way to really know is to make tests with a real voice signal. I did such tests some 30 years ago and no one was able to say whether I was using RF or AF clip-

Model	5 kHz		20 kHz		100 kHz	
	RX (dBHz)	TX (–dBc/Hz)	RX (dBHz)	TX (–dBc/Hz)	RX (dBHz)	TX (–dBc/Hz)
IC706 (02803)	92.6	91.0	107.7	108.3	125.8	125.4
IC706MKIIG (04668)	106.8	103.8	118.7	117.2	132.3	125.0
IC821H (01942)	97.8	95.8	113.7	113.1	129.0	127.7
IC970H (LA3FV)	102.7	100.1	123.7	121.6	140.7	132.0
FT100 (9E032006)	108.6	107.6	118.9	119.0	130.6	129.4
FT817 (0N110101)	103.3	101.3	118.2	117.2	132.6	130.4
FT847 (LA9CM)	99.9	96.0	116.9	115.0	131.9	130.4
TM255E (51100675)	128.8	116.2	136.9	122.3	144.5	125.5
TS850S+conv (LA6MV)	112.6	113.9	125.6	129.2	138.8	133.8

Table 3. Comparison of receiver reciprocal mixing and transmitter composite noise. Data from the Scandinavian VHF/UHF meeting in Gavelstad Norway, June 2003.

Model	Band (MHz)	Noise Sideband in –dBc/Hz 5 kHz	10 kHz	15 kHz	20 kHz	50 kHz
DSW40 (SM4MJR)	7	130.5	130.5	130.5	130.5	130.5
DX70TH (T005735)	14	105.1	113.8	118.0	120.5	127.7
DX77 (T002056)	14	101.4	112.1	117.4	120.5	128.9
IC706MKIIG (06034)	14	110.9	118.4	—	124.3	129.3
IC706MKIIG (04668)	14	112.3	118.8	—	122.2	123.7
IC706MKIIG (06230)	144	103.6	112.0	115.9	118.1	125.6
IC718 (03011151)	14	111.7	118.6	122.2	124.3	130.6
IC756PROII (01690)	14	117.4	125.4	129.8	131.7	136.3
IC765 (02576)	14	121.3	126.7	128.4	129.0	130.1
IC7800 (0301012)	14	120.9	131.9	136.1	137.8	142.4
IC910H (01533)	144	96.9	106.2	111.1	113.7	121.3
FT1000D (3F320079)	14	108.1	116.1	—	127.9	130.4
FT1000D (3G330126)	14	107.7	115.0	117.8	120.0	124.7
FT1000MPMV, 200W (4D570081)	14	114.8	123.7	126.8	128.4	130.0
FT1000MPMV, 20W, AB (4D570081)	14	112.3	114.8	115.0	115.0	115.5
FT1000MPMV, 20W, A (4D570081)	14	112.1	114.2	114.4	114.2	114.2
FT726R (3I050222)	144	111.3	123.6	128.2	129.5	130.7
FT736 (9E260294)	144	115.7	123.7	126.7	128.4	130.8
FT817 (1E270433)	14	107.3	115.2	119.6	122.8	128.8
FT817 (1D240059)	144	101.7	110.6	114.8	118.0	126.7
FT817 (1E270433)	144	101.0	109.6	114.2	117.4	126.0
FT847 (81100231)	14	105.6	117.2	124.9	129.3	136.4
FT847 (81100231)	144	94.3	107.3	112.7	116.1	125.2
FT857 (3J130041)	144	101.2	111.2	116.1	119.6	126.7
FT857D (4D200054)	144	101.2	111.4	116.5	119.8	126.9
FT897	14	109.9	120.2	125.8	128.4	127.3
K2 (03903)	14	114.6	117.8	118.9	119.1	120.0
K2+conv (03903)	144	113.7	119.3	121.9	123.9	128.0
MFJ9020 (SM4MJR)	14	127.3	133.1	135.3	136.6	138.7
Orion (03C10433)	14	128.2	127.1	126.2	125.2	119.8
SW30+ (SM4EPR)	10	134.6	136.1	136.8	137.0	137.0
TR9130 (3040284)	144	116.3	125.6	129.7	132.3	135.9
TS2000 (21000340)	14	109.4	117.8	—	123.1	126.2
TS2000 (30400028)	14	108.6	117.8	119.6	121.1	124.1
TS2000 (50600050)	14	110.3	118.3	121.5	123.0	125.4
TS2000 (30400028	144	105.3	115.3	119.8	122.6	131.0
TS2000 (50600050)	144	104.7	112.9	117.2	120.6	129.7
TS450S (60700160)	14	110.6	120.0	—	125.6	128.4
TS50 (41000988)	14	109.6	114.2	115.2	115.9	116.7
TS711E (8070268)	144	114.0	121.1	124.3	126.0	130.8

Table 4. Transmitter sideband noise levels. The values given are the largest values measured at or above the corresponding frequency separation, so this table gives the frequency offset beyond which there is no wideband interference (splatter) above the level given in the table.

ping. I did these tests at marginal signal levels only. For strong signals it is easy to hear the difference, but you have to remember that intelligibility is not the same thing as a pleasant "hi-fi" sound. Recently, I verified these findings with computer simulations. There is a difference, but it is not large. The speech-processing simulation is included in Linrad-01.25 (and later versions) as part of the setup for transmit routines. You can download it from <http://www.sm5bsz.com/linuxdsp/linroot.htm>[5] and make your own tests to find out how clipping and filtering affect intelligibility with your own voice.

The reason for bringing up the merits of audio clipping is that modern transceivers actually use RF clipping without filtering after the clipper by means of a fast ALC system. It has been used for decades, in transceivers such as the FT-225 for example ,[2] but it is and it always has been a bad idea because of all the off-channel interference generated. All rigs designed like this should be modified to make the speech clipping occur on the correct side of the bandwidth-defining filter. For the FT-225 this is particularly easy,[2] but it is pretty easy in other rigs also. Basically, one can reduce the gain of the amplifier immediately after the filter until the ALC becomes inactive. There will still be something ahead of the filter that limits the signal level and serves as a clipper, but it does not matter if it is an audio amplifier, the SSB generator, an RF amplifier, or mixer. Anything that limits the peak power at the right side of the filter—before the input—is fine. It is extremely easy to reduce the gain after the SSB filter. Just send some DC into the ALC input to make the ALC meter permanently show its normal peak voltage.

Carrier Sideband Noise

The wideband noise surrounding a strong carrier is often the limitation on VHF bands. Such sidebands are usually referred to as phase-noise sidebands because it is assumed that they originate in the phase noise of a local oscillator. Transmitters are typically not even as

good as the quality of the LO would allow, because inadequate noise figure of the transmit amplifiers plays an important part, and such noise modulates the amplitude as much as the phase.

As was pointed out in the article "Receiver Dynamic Range,"[6] the first article of this series, in order to make sure that no part of the transceiver unnecessarily limits the overall performance, the two-signal receiver dynamic range (in dB for 1-Hz bandwidth) should be equal to the LO phase-noise suppression (in dBc/Hz).

The transmitter sideband noise should also have the same value, if it is correctly designed and does not add needless noise from poorly designed amplifiers. Remember also that each of these performance figures is valid only at a given frequency offset from the signal frequency. Table 3 shows the two-signal dynamic range and the transmitter sideband noise levels of some typical 144-MHz transceivers, at three different frequency offsets.

I think it is because this kind of performance information is not made public in transceiver testing that the manufacturers see no reason to design the transmitter carefully. I am sure it would be very easy to cure problems of this kind at the design stage and that it would not lead to higher production costs.

At the 2003 Scandinavian VHF/UHF meeting I only made systematic measurements on receivers. At subsequent meetings I have mainly made measurements on transmitters, because transmitter spectral purity is becoming the limiting factor for dynamic range on VHF bands. Table 4 shows the sideband noise of various transceivers collected at several amateur meetings.[7]

HF transmitters typically have lower noise at close separation than VHF transmitters. This is a natural consequence of a lower LO frequency. At large frequency separations, on the other hand, VHF transmitters are typically better than HF transmitters. Maybe it is because engineers designing at VHF frequencies are more aware of amplifier noise performance, but HF engineers simply assume it will be okay.

State of the Art: What is Good and What Needs Attention

It seems to me there is a general consensus that HF receivers have adequate dynamic range.[8] HF receivers also are not often limited by the two-signal dynamic range, and therefore some degradation may be harmless. On crowded HF bands the challenge is in the summed power from a large number of strong signals (including broadcast signals on 40 meters). The performance at very close frequency separation may need some attention—e.g., CW operators on the extremely crowded low-frequency bands may need a good intermodulation dynamic range at strong-signal separations as close as 0.5 kHz, and I have been told that many modern rigs fail badly at such close separations.

However, HF transmitters are very unsatisfactory. The bad habit of using the ALC as a wideband modulator distorts both CW and SSB waveforms, and generates emissions that often degrade the transmitter dynamic range by 40 dB and even more. This is not quite as bad as the number indicates, because the ALC-generated sidebands have a high peak to average power ratio, and it is possible to hear signals that are much weaker than the splatter peaks or keying clicks—unless, of course, these peaks are strong enough and long enough to capture the AGC of the receiver.

On VHF it is different. Neither transmitters nor receivers have the dynamic range required for several operators in the same city area to operate simultaneously without mutual interference. Even at large frequency separations, they are far from achieving this goal. However, there is no good reason why any VHF LO synthesizers should be notably worse than the best ones (for example, the synthesizer used in the TM-255). It typically is easy to modify the oscillator of any 144-MHz transceiver to this performance level. As an example, LA6LCA has modified the VCO in his TR-9130, and the two-signal dynamic range of the modified unit is 147.8 dB_{Hz} at a frequency separation of 100 kHz and above.

I think the weak-signal VHF community would benefit greatly if the manufacturers would receive this message from the market: "We will only buy transceivers that have a transmitter and receiver dynamic range better than 140 dB/Hz at a separation of 100 kHz as soon as at least one such unit becomes available." Compared to the current state of the art, the improvement needs to be 15 to 30 dB—especially on the transmitter side—and it would make a significant difference to many of us.

Finally, there is no reason why such improvements should make the rigs significantly more expensive. At the present, what is missing is not costly hardware, but rather some thought and attention from the designers. ■

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6. Leif Åsbrink, SM5BSZ, "Receiver Dynamic Range," *DUBUS* 4/2003 pp. 9–39; also *CQ VHF*, Fall 2004 and Winter 2005 issues, parts 1 and 2, respectively.

7. <http://www.sm5bsz.com/dynrange/rig_compare.htm>

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Moondata Update 2006 and Related Comments

One of the most important factors in EME communications is knowing when it is best to communicate via moonbounce. W5LUU presents a summary and table of the best and worst conditions for EME in 2006.

By Derwin King,* W5LUU

The earth-moon distance and the cosmic (sky) noise temperatures in the direction of the Moon are predictable cyclical variables that set basic day-to-day quality of the Earth-to-Moon path for communications at frequencies below 1.0 GHz. Best conditions occur when: (1) the Earth-Moon distance is at an absolute minimum, and (2) the Moon, as viewed from Earth, is in the coldest part of the sky. This rarely occurs. The EME signal-to-noise ratio, in dB, is usually degraded by a factor, DGRD (see below), which varies slowly with time. The 144 and 432 DGRD factors (in dB) and other pertinent EME data are tabulated in W5LUU Weekend Moondata at 0000 UT on each Sunday of the upcoming year. These are useful as a general guide to the basic EME weekend conditions. Ionospheric disturbances, local noise, polarization mismatch, and scattering properties of the Moon may make DGRD higher. The Range Factor is equal for all frequencies. Sky temperature is greater at 50 MHz than on 144 and lower on 1296 and higher than on 432.

In early 2006 the average DGRD remains high as Moon apogee occurs in the cold sky region, but by the end of the year this will reverse. In September Moon perigee occurs at a northern declination for the first time in many years. This continues for the remainder of 2006—and for the next several years. Five *good* weekend days occur in the first half of 2006 and eight in the second half. No weekend days are rated any better. However, these will be coming next year and for a few years thereafter. Contest dates for 2006 need to be carefully coordinated if all interest groups are to be fairly accommodated within the few feasible weekends.

Definitions

DEC (deg): Moon declination in degrees north and south (–) of the equator. This is cyclical with an average period of 27.212221 days. The maximum declination during a monthly cycle is also cyclic, with a range of 18.15 to 28.72 degrees and a period of about 19 years. *Next maximum is on 09/15/2006.*

RA (hrs): Right ascension in hours. The east-west position of the Moon against the sky background. Average period of RA cycle is 27.321662 days, but it can vary by a day or so.

144 MHz Temp (K): The 144-MHz cosmic noise in direction of the Moon expressed as absolute temperature.

Range Factor (dBr): The additional EME path loss (in dB) due to Earth-Moon separation distance being greater than absolute minimum (348,030 km surface-to-surface). Varies from 0 to 0 .7 dB at perigee, to 2.33 ±0.1 dB at apogee.

DGRD (dB): The degradation in EME signal-to-noise (in dB) due to: (1) the excess sky noise temperature (in dB) at the listed position of the Moon compared to the lowest cold sky temperature and the system noise temperature (all at the frequency of interest); plus (2) the Earth–Moon range factor (dBr) for the listed time and date. The tabulated DGRD is referenced to the lowest possible sky noise temperature along the Moon path, to a system noise temperature of 80K at 144 MHz and 60K at 432 MHz, an antenna beam width of ~15°, and to the absolute minimum Earth-Moon (surface-to-surface) distance.

The dBr affects DGRD equally at 144 and 432 MHz, but at 432 MHz and higher sky noise effects are lower. During a monthly lunar cycle DGRD can vary up to13 dB on 144 MHz and 8 dB on 432 MHz. DGRD varies less with small antennas than with large ones.

Moon Phase: Shows New Moon (NM) and Full Moon (FM) along with the number of days (d) or hours (h) before (–) or after (+) these events. At NM sun noise is a problem, while at FM the night-time conditions are usually more stable.

Conditions: Summary of EME conditions as controlled by DGRD at 144 MHz and NM. Conditions may be worse, due to ionospheric disturbances, but not better than indicated. In general, 144 MHz DGRD <1.0 dB is considered Excellent, 1.0 to 1.5 is Very Good, 1.5 to 2.5 is Good, 2.5 to 4.0 is Moderate, 4.0 to 5.5 is Poor, and over 5.5 is Very poor. Within a day of New Moon (NM), high sun noise can make conditions Very Poor regardless of the DGRD.

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The information and accompanying table are printed here in CQ VHF *on a non-exclusive basis courtesy of Derwin King, W5LUU*

W5LUU Weekend Moondata for 2006
For Sundays at 0000 UTC

2006	DEC (deg)	RA (hrs)	144 MHz Temp. (°K)	Range Factor (dBr)	DGRD (dB) 144 MHz	DGRD (dB) 432 MHz	Moon Phase	Conditions
Jan 01	–26.4	19.6	528	0.32	4.3	1.6	NM + 21h	Poor
08	14.4	2.0	322	1.17	3.3	1.7		Moderate
15	24.4	8.3	202	2.19	2.8	2.3	FM + 14h	Moderate
22	–10.9	13.5	322	1.92	4.1	2.3		Poor
29	–24.1	20.3	360	0.17	2.7	0.9	NM – 14h	Moderate
Feb 05	18.6	2.6	359	1.14	3.7	1.8		Moderate
12	21.8	8.9	170	2.29	2.4	2.3	FM – 1.2d	**Good**
19	–14.9	14.0	349	1.94	4.4	2.5		Poor
26	–22.2	20.8	334	0.20	2.5	0.8	NM – 2d	**Good**
Mar 05	22.0	3.2	362	1.04	3.6	1.7		Moderate
12	18.7	9.5	183	2.32	2.6	2.3	FM – 3d	Moderate
19	–18.8	14.6	391	1.87	4.7	2.6		Poor
26	–19.3	21.4	345	0.36	2.7	0.9	NM – 3.5d	Moderate
Apr 02	24.4	3.8	362	0.97	3.5	1.6		Moderate
09	15.3	10.1	188	2.30	2.7	2.3		Moderate
16	–22.2	15.3	436	1.71	4.9	2.6	FM + 2.5d	Poor
23	–15.4	22.0	276	0.55	2.2	1.0		**Good**
30	26.3	4.4	398	1.02	3.9	1.8	NM + 2.2d	Moderate
May 07	11.7	10.6	201	2.26	2.8	2.4		Moderate
14	–24.8	15.9	506	1.47	5.3	2.5	FM + 0.7d	Poor
21	–10.7	22.7	244	0.66	1.9	1.0		**Good**
28	27.6	5.0	467	1.19	4.7	2.2	NM + 0.8d	Poor
June 04	7.9	11.0	211	2.24	3.0	2.4		Moderate
11	–26.7	16.5	708	1.23	6.3	2.5	FM - 0.75d	Very Poor
18	–5.3	23.4	244	0.65	1.9	1.0		**Good**
25	28.3	5.6	512	1.43	5.2	2.7	NM – 0.7d	Poor
July 02	3.9	11.5	235	2.26	3.3	2.4		Moderate
09	–27.9	17.2	1199	1.06	8.2	3.2	FM – 2d	Very Poor
16	0.0	0.0	252	0.54	1.9	1.0		**Good**
23	28.4	6.3	440	1.67	4.9	2.8	NM – 2d	Poor
30	–0.2	12.0	260	2.30	3.7	2.6		Moderate
Aug 06	–28.5	17.8	2619	0.99	11.4	5.0	FM – 3.5d	Very Poor
13	4.9	0.5	271	0.57	1.9	0.8		**Good**
20	27.6	7.1	358	1.84	4.4	2.5		Poor
27	–4.4	12.5	312	2.33	4.4	2.9	NM + 3.2d	Poor
Sept 03	–28.5	18.4	2247	1.04	10.8	5.4		Very Poor
10	9.1	1.1	285	0.21	1.9	0.6	FM + 2.2d	**Good**
17	25.9	7.8	257	1.92	3.3	2.2		Moderate
24	–8.6	13.0	314	2.31	4.4	2.8	NM + 1.5d	Poor
Oct 01	–27.6	19.1	828	1.13	6.8	3.4		Very Poor
08	12.8	1.6	300	0.16	2.1	0.6	FM + 21h	**Good**
15	23.5	8.4	196	1.91	2.4	2.0		**Good**
22	–12.6	13.5	325	2.22	4.4	2.7	NM – 5h	Poor
29	–25.7	19.8	470	1.18	4.7	2.3		Poor
Nov 05	16.3	2.1	329	0.27	2.5	0.8	FM – 6h	**Good**
12	20.7	9.0	166	1.87	1.9	1.8		**Good**
19	–16.2	14.1	354	2.10	4.6	2.6	NM – 1.9d	Very Poor
26	–22.7	20.5	339	1.11	3.4	1.7		Moderate
Dec 03	19.7	2.7	360	0.52	3.1	1.2	FM – 2d	Moderate
10	17.6	9.5	182	1.85	2.1	1.8		**Good**
17	–19.5	14.6	390	1.99	4.8	2.7		Poor
24	–19.0	21.2	339	0.89	3.2	1.4	NM – 3.4d	Moderate
31	23.1	3.3	360	0.81	3.3	1.4		Moderate

A Telemetry Beacon, Digital Camera, and Controller System for Experimental High-Altitude Balloon Flights

Here WC5Z describes a simple and inexpensive flight payload system for experimental high-altitude balloon flights.

By Michael Helm,* WC5Z

The payload described in this article includes a simple 2-meter FM/CW telemetry beacon transmitter, an automated IDer/controller which can provide up to 16 different CW telemetry status messages and also control an inexpensive digital camera for collecting still images at predetermined intervals during a balloon flight. This total system design has successfully flown in two recent flights. The total payload weight without batteries is about 8 ounces. —*WC5Z*

High-altitude experimental balloon flights have been described elsewhere in the literature. This article covers the design of a small multi-purpose payload, which is useful to fly as a standalone payload or in conjunction with other experimental payloads. This payload includes a low-power 2-meter beacon transmitter for tracking purposes and some limited status telemetry, along with an inexpensive digital camera which will take pictures at timed intervals (photo A).

The total cost of duplicating this payload including camera and even the batteries should be less than $100. The entire system is designed to operate from a 6-volt DC power source in the interest of keeping battery weight low.

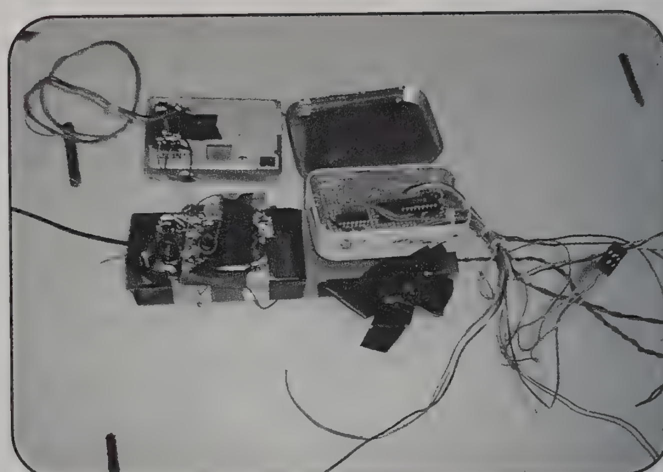

Photo A. Controller, two separate beacon transmitters, and the modified digital camera prior to final packaging before flight.

The 2-meter Beacon Transmitter

The low-power 2-meter beacon transmitter is designed around a conventional oscillator-multiplier chain[1] with the circuit as shown in figure 1. The design is based around proven technology rather than a leading-edge approach, since reliability is the most significant performance requirement. This beacon transmitter provides an FM-tone modulated signal that is on/off keyed with the CW ID/telemetry message. A simpler transmitter design has been flown that does not include the FM audio tone, but many of the casual balloon trackers only have FM equipment and the signal is more pleasant for those trackers if the FM tone modulation is included. The FM tone modulation does not significantly hinder those who are using SSB/CW receivers for tracking.

The transmitter starts with a 12.288-MHz surplus crystal that can be obtained for very low cost. The first stage is an oscillator-tripler; the next stage doubles to the 72-MHz region. Following is a doubler stage to 147.456 MHz which feeds a single amplifier stage. Double-tuned circuits are used in most stages to provide for good signal purity. Although it is possible to eliminate some of the double-tuned circuits, I have found this often results in close-in spurious signals plus or minus the fundamental crystal frequency from the desired final carrier frequency. Double-tuned circuits add little to the total cost and weight and are very desirable from a clean-signal standpoint. Even though this transmitter only produces about 25 mW when operated from a 6-volt DC power source, since it will be flown at up to 20 miles of altitude it is very important for its output to be spurious free. The spurious-emissions requirements of FCC Part 97 are tighter than you might think, even for a low-power transmitter such as this in this frequency range. Even at this low power, harmonics and spurious emissions must be down about 38 dB and have to be down 40 dB if the power is as high as 100 mW.[2] I use a spectrum analyzer for final tuning of these transmitters and would recommend that you do the same if you choose to duplicate this design for your own flights. I have built several transmitters similar to this one and all have met the FCC Part 97 spurious-emissions requirements when properly tuned, but just tuning for maximum power out may not achieve a clean output.

At the output, a low-pass filter is included. I feed the signal from the output into either a standard half-wave dipole or an

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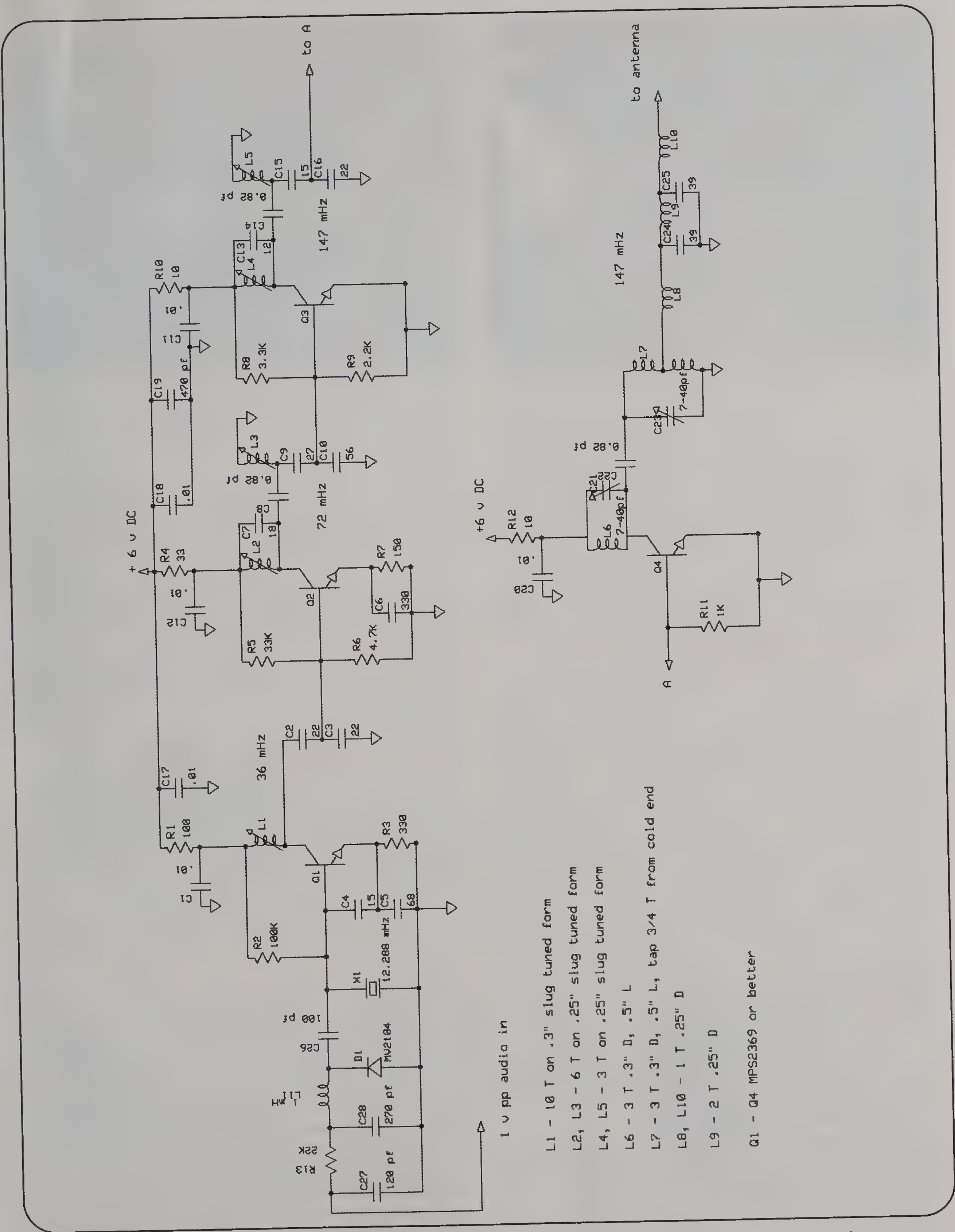

Figure 1. One version of the simple FM/CW beacon transmitter. This version will produce about 25 mW of output power. One more amp stage can easily bring this up to more than 100 mW.

Photo B. Image from ARSAT's April 9, 2005 flight. This one is looking down on farmland near I-27 and Hale Center, Texas.

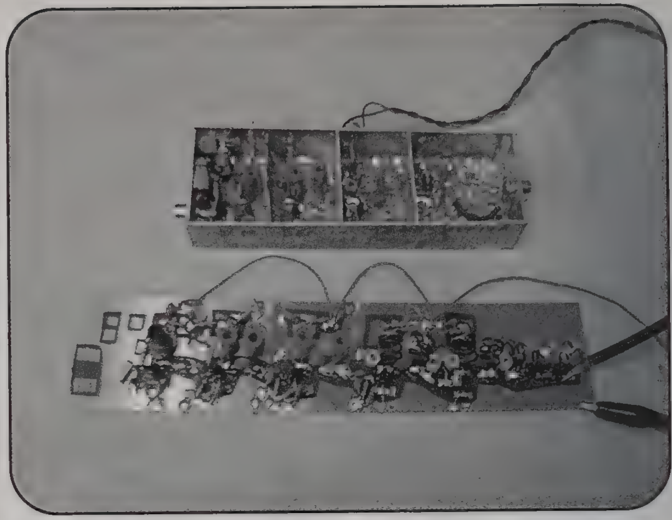

Photo C. A breadboard-version beacon transmitter in the foreground and an earlier packaged unit without the lid in the background.

end-fed dipole made from RG-174 miniature coax, depending on the needed flight configuration. I prefer to put the antenna at least a few feet away from the IDer/controller electronics if possible to prevent RF from interfering with the controller. If the antenna needs to be close-in, then the controller can be shielded in an Altoids® can or some other shielded container. Photo A shows the 2-meter beacon transmitter along with another beacon transmitter on a different frequency band and the IDer/controller, which is mounted in an Altoids can for shielding. I solder the lid shut prior to packaging for flight.

The FM audio modulation is achieved with the varactor diode and a source of about 1-volt pp of audio tone. The controller described elsewhere in this article provides square-wave audio tone, or a 555 timer or other audio tone source can be used. If a square-wave audio tone source is used, it should be filtered with a low-pass RC network to provide something close to a sine wave.

The transmitter power is deliberately kept low for multiple reasons. Very little power is needed to track the beacon while it is flying. K5IS, who has much more experience with tracking than I do, has explained to me that too much power in the beacon transmitter makes it more difficult to get good beam headings while tracking the balloon in the air. The 25 mW is plenty sufficient for tracking the payload in the air and is useful when the payload is on the ground with a good mobile tracking setup if the beacon antenna is off the ground. A member of our local ARSAT (Amateur Radio Society At Tech [Texas Tech]) group, KD5UXO, developed a payload concept to keep the antenna off the ground. In this payload arrangement the antenna is attached across a large disk attached about one third from one end of a cylindrical payload mounted in the center of the disk, so regardless of how the payload lands, the antenna should never be flat on the ground. Experiments have shown this to very useful in improving the on-the-ground tracking range.

Another advantage of lower power is much longer battery life. The estimated battery life on our most recent ARSAT flight was eight days with this payload, and could have been of great benefit had the payload been lost.

I have built several variations on this design. Some have included additional power gain stages and have achieved up to about 200 mW of output power when using a 12-volt DC power source. If the reader wants more power than provided by the circuit shown, I would recommend using transistor(s) with a better gain bandwidth product and one(s) that can dissipate more power in the additional stage(s). The circuit shown is the result of several empirically derived beacon transmitters built over a period of several years. One very critical consideration in these types of designs is to use a very low-value coupling capacitor between the double-tuned resonators. If this value is increased above about 1 pF, it is very hard to achieve a clean output signal. I am sure there are better beacon transmitter designs available, but this is one which I have had the enjoyment of developing in an empirical fashion, and the design(s) will continue to evolve as I continue to experiment with them.

Multipurpose IDer/Controller

A single micro-controller chip, the PIC16F84[3], is the core of the IDer and the camera controller. This less than $5 component provides the automated beacon ID, provides for up to 16 different pre-amble messages to indicate the status of four digital input bits, provides the control signals to control the power and shutter for an inexpensive digital camera, provides for security lockout, and provides the potential for timed payload release or other timed event during flight. The keying for the beacon transmitter is provided in two forms, either on/off keying or audio tone.

The PIC16F84 can use either a crystal-controlled clock or an RC-controlled clock. I use an RC clock since it is less expensive and also provides the ability to provide relative temperature telemetry by including a thermistor in parallel with the clock resistor as shown in figure 5. This causes the CW ID message to become slower at lower temperatures, and when it speeds up, it alerts trackers that the payload is descending. An alternative way to telemeter this information is to use the thermistor on the audio tone source for the FM modulation.

The PIC16F84 has a total of 13 I/O pins. These can be assigned individually as inputs or outputs. Outputs include beacon transmitter on/off keying, camera power control, camera shutter control, and an optional payload-release timed signal. Inputs include a security power-up feature, and four digital on/off status bits which select one of 16 preamble messages.

This allows a limited amount of status information to be sent on every ID cycle.

The security power-up feature provides some security for the callsign owner in case this payload is not recovered. A certain sequence has to occur during power-up of the unit in order for the beacon to transmit or the camera to start taking pictures. Basically, if the unit is powered up without a special signal jumper in place, the unit simply will halt and never key the beacon transmitter nor take any pictures. If the jumper is in place at power-up, the beacon will begin to send the letter V in Morse Code, but will not take any pictures. When beacon signals are confirmed after power-up and flight is imminent, the special jumper is removed and the controller will start the normal ID sequence, including the preamble message indicating the status of the four digital input bits. After the jumper is removed, the camera sequence will start and will take a picture once each ID sequence. Because the camera has automatic power-down after about 30 seconds, it is necessary to turn on the power to the camera for every picture and then toggle the shutter. The ID sequence includes one very long key-down time to assist the trackers in getting good bearings. The total ID cycle takes about one minute at nominal temperature and yields one picture for each ID sequence.

The Camera and Interface

The camera is a very inexpensive (approximately $20) unit obtained from a local Walmart store. This unit will store about 75 pictures of 640 × 480 pixels and is very sufficient to obtain interesting photos from the payload. The camera uses two internal AAA batteries, and apparently they have worked okay even at the cold temperatures during two recent flights. To provide the interface, the power and shutter switch connections are determined after disassembling the camera. I used small reed relays to control those signals. This provides a very clean interface to the PIC16F84, which will directly drive the relays. I got the idea about the camera from a couple of articles by Paul Verhage in *Nuts & Volts*.[4,5]

Conclusion

This design provides a simple, lightweight, and inexpensive payload for experimental high-altitude balloon flights. It is suitable as a standalone payload or a supplemental payload. Because it runs on 6 volts DC and averages less than 60 mA of current consumption, it can run for several days on a good set of lithium batteries. The long battery life may be beneficial in the event of initially lost payload.

Experiments have been run to determine the range of the beacon transmitter once the payload is on the ground. With the antenna lying on the ground, it can be received about 1 mile with a simple FM mobile setup. With the payload configured so that the antenna will always be off the ground, a good mobile tracking setup with SSB/CW receiver and multi-element Yagi can track it 5 or 6 miles, depending on actual beacon power. A recent flight by the ARSAT group in Lubbock, Texas includ-

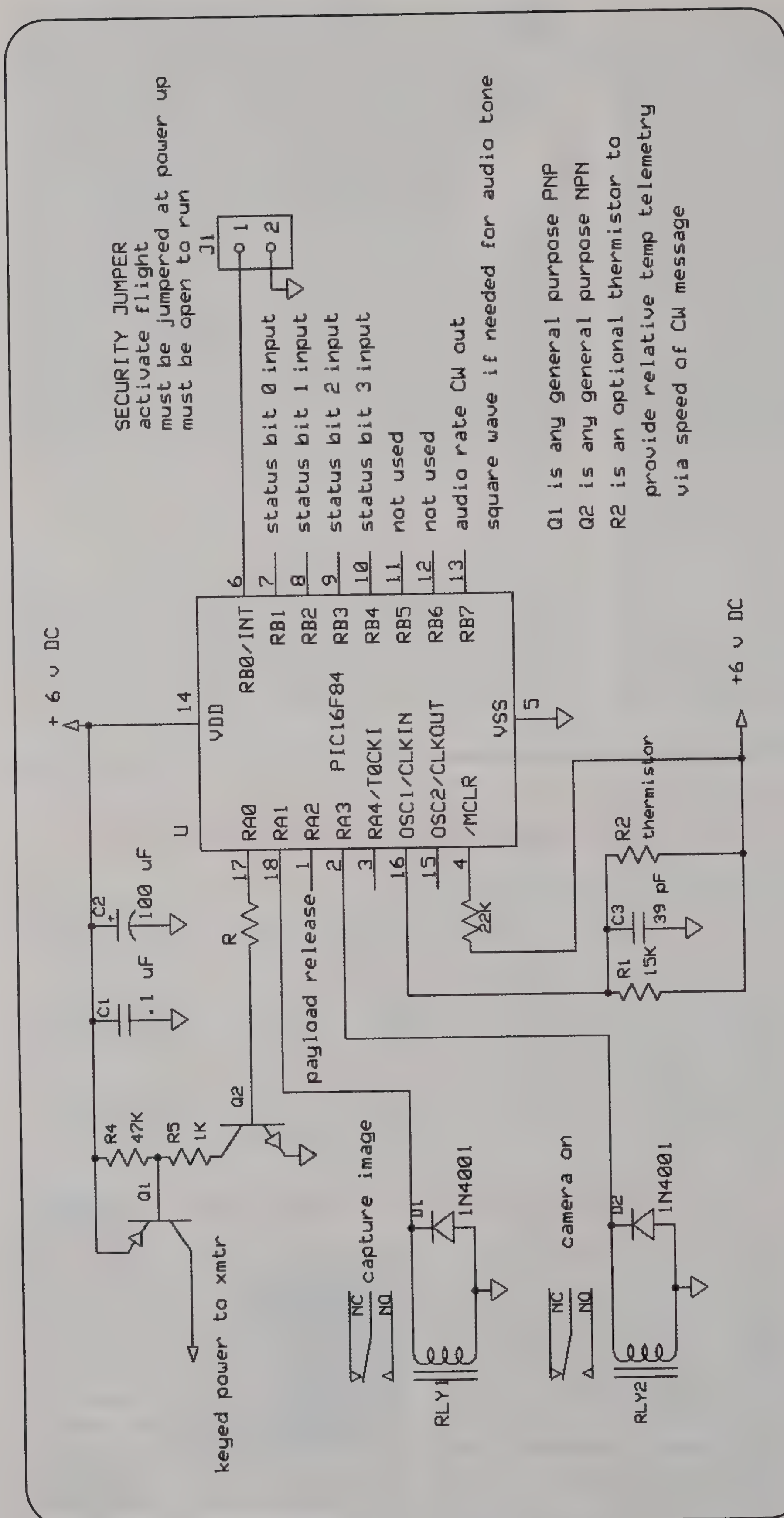

Figure 2. The beacon and camera controller.

ed only this payload and was successfully recovered within 30 minutes of payload down. Without the beacon transmitter, recovery would likely not have occurred. This payload is also suitable as a backup to GPS/APRS payloads.

In another recent flight with the K5IS group near Booker, Texas, a payload similar to this one was flown as a supplemental payload, and yet proved to be useful during a brief time when the APRS payloads had failed temporarily (due to cold temperatures?). This payload at least gave us a reasonable indication of where the balloon was and that at least some things were still functional. The beacon transmitter/ IDer did briefly enter a continuous key-down mode at the top of the flight, but recovered. Since the transmitter and controller were not insulated, cold temperatures are suspected as the source of that brief problem.

Other beacon transmitters have been designed and flown, including 12-volt DC versions of the same general design and a simpler CW-only beacon that used a 49-MHz-region crystal and that required fewer multiplier stages, hence a smaller, simpler, lighter weight beacon. I am currently working on a 440-MHz design and a 915-MHz design, but those are still in the development phase and have not flown—yet. This general beacon transmitter design has now flown a total of four flights, and the IDer/controller has now flown three flights. In all cases the systems performed well with the one brief failure mentioned above.

The assembly language source code for the PIC16F84 will be available on my website at: <http://www.cs.ttu.edu/~mhelm/balloonBeacon2005.asm>. The code is reasonably well documented and should be self-explanatory.

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[5] L. Paul Verhage, "Updates on Modifying Cameras for Digital Control" Near Space column in *Nuts & Volts* magazine, T&L Publications Corona, CA, March 2005. ■

CQ's 6 Meter and Satellite WAZ Awards

(As of September 31, 2005)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3.6,7,10,12,18.19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13.19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27.28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40
71	EH9IB	1,2,3,6,10,17,18,19,23,27,28
72	K4MQG	17,18,19,21,22,23,24,25,26,28,29,30,34,39
73	JF6EZY	2,4,5,6,9,19,34,35,36,40
74	VE1YX	17,18,19,23,24,26,28,29,30,34

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

*17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

T-Hunting Then and Now
From Gooney Birds to GPS

For over 40 years, hidden transmitter hunters have prowled the streets in search of the elusive sources of unusual signals. Equipment has evolved, but the adventure and intrigue remain the same.

By Joe Moell,* KØOV

To me, the best thing about ham radio is that it's not just one thing. Our hobby offers a myriad of bands, modes, and activities, each with its own group of dedicated followers and proponents. I've tried most of them and they all are a blast. However, to me, nothing can compare with the excitement of hidden-transmitter hunting.

When you set out on a mobile transmitter hunt (which southern California hams call a "T-hunt"), you never know where you'll end up and you never know what you'll find there. What surprise awaits today? On-foot hunts are an equal challenge, where you can improve your physical conditioning and perhaps win medals in international competitions.

Transmitter hunting is far from new in amateur radio. *QST* magazines of the 1930s tell of on-foot hunts at ARRL conventions, where hams used rudimentary equipment—just a galena crystal across the terminals of an earphone—to "sniff" out a signal source.

The heyday of T-hunting began a half-century ago, when gasoline was cheap and the open road beckoned. A ham would take a portable transmitter to an unlikely location and put it on the air. The hunters, usually all starting from the same location, would try to see who was best at radio direction finding (RDF). Each hunt was a test of construction skills as well as tracking abilities, for no commercial RDF gear was available.

I went on my first T-hunt as a 12-year-old Novice. On the rolling plains of Nebraska where I lived, the not sensitive 2-meter rigs of the day could hardly talk from one town to the next. Therefore, our Novice 2-meter voice privileges went unused. Local hams kept track of one another on the 75-meter phone band. Some of them had upgraded to the latest in ham technology—single sideband. The natural place for a transmitter hunt was right there on 75.

I was working toward my General Class license, learning to draw RF oscillator and amplifier schematics from memory, as was required back then. My pride-and-joy Hallicrafters SX-100 receiver was all I had for 75 meters, so I built a vibrator power supply for it out of junk car radio parts. It sat on the seat of the family convertible, with the wicker-weave antenna from an old AM radio up on a pole that I held high. Dad had to drive, of course. The antenna directivity was not good and we didn't find the transmitter, but I was hooked. Unfortunately, the local club never had another hunt until after I graduated from high school.

Follow the Winking Green Eye

At the same time in southern California, hams had discovered the delights of T-hunting on VHF. David Pepper, WA6TWA, was also age 12 when he first took a Saturday night ride to experience it. He had heard about it from Hal Rattray, WA6SZY, who lived across the street. For David's first hunt, he was relegated to the back seat of Hal's car, where he kept track of the flashlight and maps.

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Getting back into the game, David Pepper, WA6TWA, sniffs out a hidden transmitter using a state-of-the-art 2-meter RDF set from Australia. (All photos by Joe Moell, KØOV)

"All of the cars were equipped with receivers, signal-strength meters, and other electronic gadgets," says David. "They also had strange-looking antenna rotating devices and handheld aircraft landing lights to show the way. The antennas ranged from beams, which looked like housetop TV antennas, to helicals with futuristic-looking spiral copper tubing protruding from dish-like structures."

T-hunting had become a popular sport in the City of Angels, attracting 10 to 20 cars for each hunt. Inside were two or three people. The driver concentrated on the road while the others handled all the gear and maps. Some attached their antennas to a window mount, while others had to stop and get out of the car to get bearings.

Before the hunt, an organizer would record every vehicle's odometer reading. The most popular hunts were scored by mileage from start to finish, to encourage safe driving and careful map reading. Occasionally there were hunts in which the first-to-find was declared winner and mileage didn't count, but

these "road races" weren't as popular. Afterwards, everyone headed to the famous Bob's Big Boy restaurant for treats, war stories, and mileage calculations.

According to WA6TWA, "Bulky and heavy vacuum-tube AM gear was the order of the day. Commercial transceivers included Heathkit Pawnees and Gonset Communicators, or 'Gooney Birds' as they were called. The Gonsets had a weird fluorescent-green 'eye' tube. Its glowing pattern would open and close depending on the signal strength. This winking eye added intrigue to the strange chirping tones that assaulted my ears that night.

"We started at Darby Park near Hollywood Race Track," David continues. "Bearings were in the northerly direction. Some teams shot for the moon and headed toward Mount Wilson by freeway, hoping that the transmitter was in the mountains and they could minimize mileage through the city. We took a more conservative route along the side roads, taking antenna bearings every mile or so and ending up in the Verdugo Hills above Glendale, 20 miles from the starting point.

"As we got closer to the transmitter, the warbling, chirping sounds from our rig became more and more intense and the meters began to peg. Occasionally, the hidden operator would break the tension by getting on his microphone and exclaiming, 'This is the hidden transmitter, located on Mount Suribachi!'[1] Driving up the dark canyon roads on this moonless night was very exciting, but even with our aircraft landing light in hand, we were unable to find the fire road that would have led us to the pot of gold at the end of the radio-wave rainbow. Nevertheless, I had a great time."

Today's stamp-size transmitter boards make it possible to really "hide" a transmitter. Back then it was better to be in plain sight, using camouflage if necessary. Resourceful hiders had many tricks up their sleeves, as David discovered on his second outing.

"The T was cleverly placed in full view of the traffic flow along La Cienega Boulevard, brightly illuminated by streetlights above. The electronics were in a metal box with a cable emerging and neatly stretched across the street on the pavement. The antenna was attached to the other end of the cable and hidden from view in bushes.

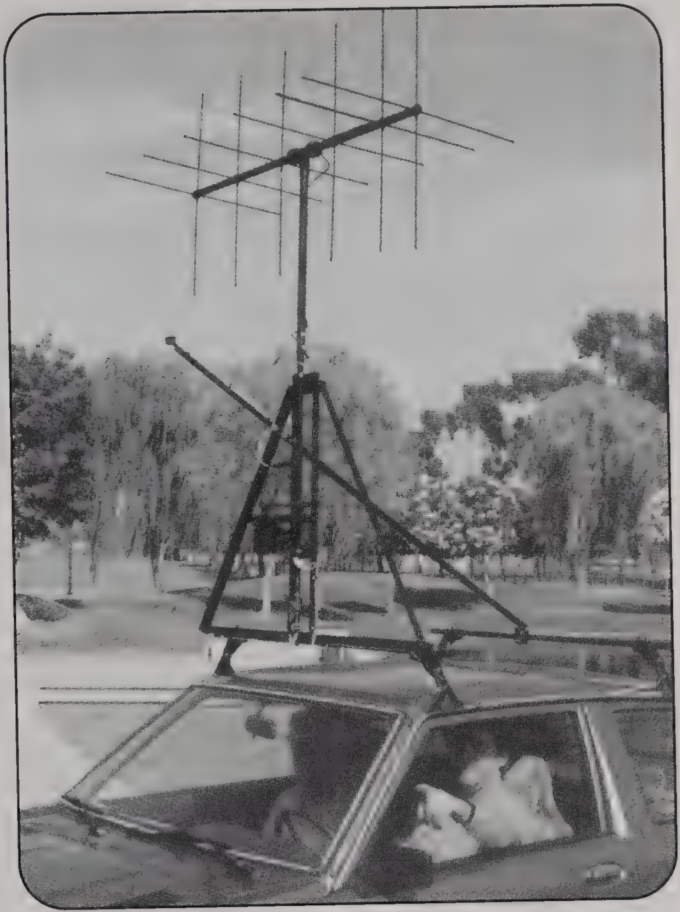
"This contraption looked just like an official traffic counter," WA6TWA explains. "Most of the T-hunters, along with the rest of the traffic flow, drove over the cable. It was not until several miles down the road that we caught on, once we got bearings pointing behind us!"

Young David sought hunt rides wherever he could get them. By accompanying many different hunters he learned what worked well and not so well. He was especially excited to get a seat with Neil McKie, WA6KLA, a top-tier hunter of the time. However, his mother was understandably concerned when the doorbell rang on that drizzly night. He says, "A 6-foot 5-inch burly man told her that he was here to pick up her precious pimple-faced, nerdy-looking 12-year-old boy whose voice had yet to change.

"In his deep, yet gentle voice Neil tried to convince my mom that all was safe and that I would be in good hands. She then asked him about the transportation. Neil proudly pointed out his T-hunt car in front of the house—a dilapidated 1940s tan-painted clunker with a strange-looking set of antenna wires out the window.

"Neil was a wonderful guy, and the T-hunt that night was a real surprise. The transmitter was right there at the Darby Park starting point in the brush. Output power was very weak to bluff everyone into thinking that it was miles away. However, Neil had a sixth sense as he drove about three blocks away from the starting point and patiently waited until the other hunters drove past. When I asked him why the delay, he told me that he had a hunch that the transmitter was closer to us than we first thought, in spite of the very weak signal.

"After taking a few more bearings, he said that it was back to the starting point for us. Once there, he took out his war-surplus portable direction finder along with his flashlight and walked around the park with me closely behind. Ten minutes later, he found the transmitter hidden in the brush and the T-hunt for us was over almost before it started. In spite of this impressive display of talent, Neil and I were humbled because the winning car turned back after only two blocks and beat us by a fifth of a mile!"

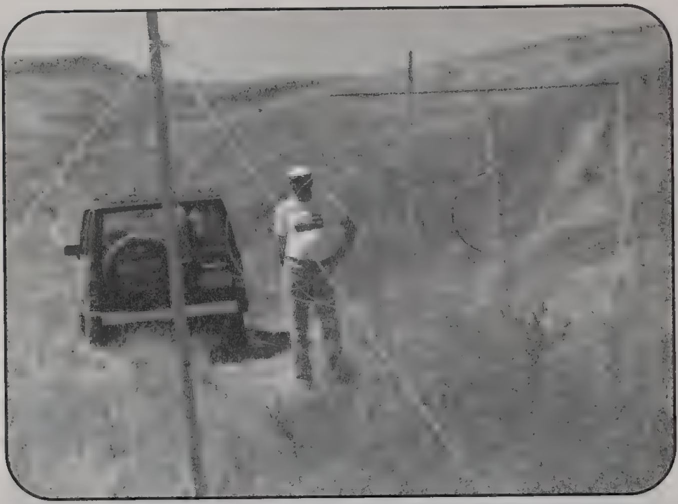


Unusual rotating VHF RDF beams are a common sight in southern California. JaMi Smith, KK6CU, built this motorized version in the 1990s. It turns at constant 6 rpm and displays bearings in polar form on a storage oscilloscope.

They've Landed!

Was it a coincidence that the hunters' vehicles looked like something from the popular science-fiction movies at local drive-ins?

"We would be routinely queried by onlookers as to what was going on," WA6TWA reports. "One of our more outrageous responses occurred on a T-hunt that took us along Hollywood Boulevard. When asked about our intent, we responded that a



Huntmasters often use exotic antennas to help their signals bounce in the southern California hills. Gary Holoubek, WB6GCT, set up this 30-foot circularly polarized 2-meter helix for a Saturday night hunt.

secret Russian Sputnik had landed in the area and we were tracking it down for the government."

That sort of flip answer may have brought trouble to some other hunters. Ken Walsh, K6ZRL, recalled, "One night several of us found ourselves under arrest, albeit briefly. We weren't doing anything illegal, but a homeowner had complained about strange people with radio gear tramping through the countryside. One hot-shot officer crashed his patrol car in the fog during that caper."

Even though it was the midst of the Cold War and many homes had fallout shelters, hams of the 1960s could hide radio gear in places that would be unthinkable today. WA6TWA says his most memorable transmitter find was in the TWA terminal at Los Angeles International Airport. He explains, "This predated the double-deck arrival/departure streets by decades. Back then, security was nonexistent by today's standards. No loudspeakers in front of the terminal urged cars and pedestrians to move on, no baggage searches were made, no security guards were on patrol, and no metal detectors or x-ray machines were to be seen.

"That Saturday night, our antenna bearings from Darby Park all pointed toward the beach. As we drove westward, we realized that LAX was to be our destination. More and more unusual cars began to pull up in front of the TWA terminal. When we couldn't find anything outside, we unmounted our antennas and equipment, then proceeded inside.

"There were three on my team, with interconnected equipment. One guy carried the buzzing vacuum-tube receiver, another carried a heavy car battery to power the mobile unit, and I held a 5-foot-long beam antenna to get directional readings. We strolled upstairs to the departure gates and eventually found the transmitter. It was in a briefcase plugged into the wall, left unattended next to a chair in the gate area just a few feet from the departure tunnel. A 19-inch coat hanger sticking out of the briefcase served as the antenna."

When David moved up to Fairfax High School, he found an active amateur radio club. Of course, he was eager to share his love of T-hunting with its members. He found a sympathetic ear in the boys vice-principal, who happened to be a ham. Mr. Alm agreed to let the club hold lunchtime on-foot hunts.

WA6TWA continues the story: "When it was my turn to hide, I decided to use the room where we met for the weekly chess club tournament. I placed my ham radio set under a desk and turned it on. Only a barely perceptible buzz came from the rig, which was transmitting the strong beacon signal. The tournament chess games continued as the hunters approached. In they came with their antennas, meters, and loudspeakers blasting away with Martian-sounding chirps."

School authorities put a quick end to that hunt, but David was undaunted. Later he found a way to go mobile without a gas-guzzling car by raiding his savings and purchasing a Honda touring motorbike. He says, "On a drizzly night I tried to T-hunt on the cycle with my old Heathkit Pawnee strapped on the rack. I stopped the bike every few miles, and using my body as if it were a reflector dish, I twisted around with a spike antenna in front of me in a futile attempt to take bearings.

"I was the joke of my competitors in cars that night. A few miles from the starting point my headlights began to dim and my engine began to sputter. I drained my motorcycle battery to a record-low charge level, but almost won the hunt. That night's transmitter was in a parking structure adjacent to the world famous Grauman's Chinese Theater in downtown Hollywood with a spike antenna dangling from the wall, a sure antenna-buster for anyone in a car."

The More Things Change...

Fast-forward to a few months ago, when WA6TWA and his wife Denise rode in my van for David's first T-hunt in three decades, and Denise's first ever. What a difference! Sensitive receivers have made high-power transmitters unnecessary most of the time. A half watt usually does it, and such a transmitter is a snap to conceal or disguise.

Hunt boundaries are much larger, encompassing over 2300 square miles on one of the Saturday night hunts. Rules of the "All-Day Hunts," which can last an entire weekend, merely require the transmitter to be within the continental USA and be copyable at the top of Rancho Palos Verdes.

A complete on-foot RDF setup with three-element beam and receiver with tone-pitch S-meter weighs around two pounds and can be carried in one hand, even by a pre-teen. Doppler RDF sets can capture and display bearings on transmissions of only a few milliseconds, but their relative insensitivity and less-than-ideal performance with horizontally polarized signals make them a secondary system for most of the hunters who use them here.

The favorite hunt vehicle is now a van or SUV. Equipment often includes laptop-based mapping software with GPS positioning. However, that doesn't mean that T-hunting doesn't require skill anymore. Hiders have learned how the local mountains can make signals bounce like billiard balls, giving false directional readings over a wide area. Instead of being continuous, typical transmissions last only a few seconds.

Much of the time there are three, four, five, or more transmitters all on one frequency, each squawking for a few seconds at a time in random sequence. On the occasional "Free For All" hunt, each participant pre-hides one or more unattended "T-boxes," as they are called. Then for a set period everyone tries to find each others' boxes. The winner is the team that finds the most.

...The More They Stay the Same

Despite all the technical improvements, former southern California T-hunters of the 1960s still feel right at home in 2005.

Jason McLaughlin, KD6ICZ, started riding along and sniffing out transmitters as he entered his teens. A decade later, he is still a fan of this ham radio sport.

Lowest-mileage scoring is still preferred, with Crenshaw Factor[2] normalization to accommodate differences in odometers. There are fewer Bob's Big Boy restaurants out there, but everyone swaps stories after the hunt at Denny's, Coco's, or Norm's.

Subterfuge, camouflage, and deceit are still prized characteristics of hiders and their transmitters. Tiny "micro-T's" have been concealed in fenceposts, soda cans, sprinkler pipes, and cell-phone cases. Once in a while, one will be a few yards from the hunters at the start point, just as WA6TWA experienced on his first hunt with WA6KLA.

Even David's derided body-reflection maneuver from his motorcycle hunt has gotten its proper respect in this decade. Hunters routinely use the "body fade" technique to get approximate heading with just a VHF handie-talkie. If you hold the HT tight against your chest and turn around, there will be a null in strength when the signal source is behind you. It's not because your body is a reflector, but because it attenuates signals passing through it. As one hunter says, "The bigger the body, the better the bearing!"

Nowadays, hunters and hiders are more conscious about security. They check on (and heckle) one another during the hunt, but they do it with their cell phones so as not to give RDF hints of their locations. "No clues!" is still the foremost rule.

Despite today's homeland security consciousness, T-hunters are rarely hassled by police. Experienced officers are used to our strange antenna arrays and slightly erratic driving. They give friendly waves as they pass by the hilltop starting points lined with hunters' vehicles, and they usually ignore the fact that a couple of them protrude into the traffic lanes.

I'm sure that as we approached the hidden T that night, David got the same thrill he had on his first hunt. I think every ham should experience this thrill at least once. T-hunting skills have many benefits for amateur radio and the public, especially in volunteer enforcement and search/rescue. For David and me, experiencing it as a pre-teen was incentive to learn more about electronics and science, leading both of us to lifelong careers. I think that's still the best part of it, so I make it a point to take young persons on hunts, mobile or on foot, whenever possible.

WA6TWA's interest in the strange properties of invisible electromagnetic waves jump-started him toward a Ph.D. in Applied Physics from Caltech and employment as a researcher in physics and optics. He sums it up this way: "Hopefully, 40 years hence there will be many middle-aged persons who will reflect back on those innocent times at the turn of the 21st century when they first tried T-hunting as a youngster."

For the latest news of T-hunting in southern California, point your web browser to <www.thunter.org>, provided by Steve Heinemann, N6XFC, and Deryl Crawford, N6AIN. For more about amateur radio RDF in general, and on-foot hunts for all ages in particular, please visit my site at <www.homingin.com>. ■

Notes

1. The famous flag-raising on the island of Iwo Jima was atop Mount Suribachi on February 23, 1945.

2. Prior to the hunt, each vehicle is driven on a standard course of approximately nine miles along Crenshaw Boulevard from the city of Torrance to a hilltop in Rancho Palos Verdes. The indicated mileage (Crenshaw Factor) is divided into elapsed mileage at the end of the hunt. The resulting Crenshaw Units for each team are compared to determine the winner. Current Crenshaw Factors for active T-hunters are posted at <http://www.thunter.org/crenshaws/newcrenshaw.htm>. ■

By Rich Arland,* K7SZ

BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

Mods for the IC-202 Receiver

Hi again and welcome back to VHF+ on a shoestring budget. If you have read the first two installments of this column, you'll undoubtedly have formed an opinion about yours truly—either I am crazier than an outhouse rat or I have a special affinity for older VHF gear that can be pressed into service at a fraction of the cost of buying new gear, or I am cheap and don't like to spend money and I enjoy doing more with less. Well, you are undoubtedly right on at least two of the three counts. I'll leave it to your imagination as to which two!

So far we have taken a critical look at what we want to do at VHF+ and have constructed a plan to bring our thinking into focus and procure some gear. Now if you are like me, you'll have been scouring e-Bay, local ham radio flea markets, and the various lists on the internet in search of gear. Just because I chose to use the 25-year-old ICOM "bookcase" radios doesn't mean you have to go that route. Yaesu, ICOM, and Kenwood all had economy-class as well as high-end VHF+ rigs aplenty in the mid 1970s through the late 1980s. Many of these radios will work quite well in your quest to get some RF gear on the high bands that can be procured at reasonable cost. Several of my non-ICOM favorites are the Kenwood TS-700A and the Yaesu FT-221R (both 2-meter multi-mode rigs) and prices are very reasonable. While they don't have all the bells and whistles of the newer multi-mode VHF+ radios, these two units are still good prime movers.

A quick look through older issues of *CQ, QST, Ham Radio Magazine,* and *73 Magazine* should yield ads and product reviews on most of this older gear. As a matter of fact, a few years back the ARRL published a set of books (*The ARRL Radio Buyer's Source Book,* Vols. 1 & 2) that were a compilation of *QST* product reviews that took in everything from HF radios to VHF/UHF rigs, accessories, and antenna rotors. Therefore, if you are really into doing some research, hit the ham radio fleamarkets and locate copies of these out-of-print books and use them for reference. Look around, do your homework, and spend your hard-earned money wisely. After all, that's the point of this entire series on VHF+ on a shoestring.

Meanwhile, Back at the Ranch…

Time to go back to the IC-202 we were working on in the last installment. The addition of the Ten-Tec speech processor module greatly increases the average RF output, so you definitely "sound" louder than with an unprocessed radio. Likewise, the simple receiver mods discussed in the last issue definitely had a positive effect on how well the IC-202 receiver played on the bands.

There is always a temptation to add a MMIC or GAsFET receiver preamplifier ahead of the radio in an attempt to make the receiver "hear better." This might be worth doing provided you don't have the technical expertise to do a couple of simple mods as outlined previously. However, you must remember that any time you add 18–20 dB of raw gain ahead of the receiver, you may end up destroying the intermodulation distortion (IMD) characteristics of the receiver.

A new DK9SQ 4-element, dual-band (2 meters and 70 cm) log periodic array designed for portable/rover use. This neat antenna collapses into a very small package for transport.

Basically, the IMD figures show how well a receiver can handle large and small signals in close proximity to one another. The added noise factor (NF) of the preamp may also degrade receiver performance by injecting significant amounts of noise into the system. While your S-meter will show a definite upswing, you may not be able to hear the target station any better due to the increase in noise levels!

Gain vs. Noise…Life at VHF

Ask those who have been in the VHF+ business for a while and they will tell you that you need all the receiver gain you can handle and then some. They are right, within reason. The old adage "you can't work 'em if you can't hear 'em" is oh, so true. However, misapplied receiver gain can be a bad thing. To fully understand where we are going with this we need to lay some ground work regarding noise, gain, and noise figure (NF), and define some terms.

All receiving systems (starting at the antenna and ending at the speaker or headphones) generate noise. This noise is a product of electrons moving within a solid-state device (transistor, FET, etc.), mixing products within the IF, synthesizer phase noise, atmospheric noise, and a host of other factors, including poor solder connections on your coaxial cables, just to name a few. This noise is cumulative and needs to be kept to an absolute minimum to be sure you can work the weak ones on the bands.

Your system noise is initially set at the antenna and increases as you progress toward the receiver. That is why experienced

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VHF+ operators insist on placing any receiver preamps as close to the antenna as possible. That way the noise factor (that little number in dB specified by the manufacturer which indicates how much noise the preamp will inject into your system) of the preamp is factored in prior to any additional noise generated by the rest of the system. If your preamp is capable of 20 dB of gain and is placed close to the radio as opposed to at the antenna, any noise generated throughout the system also will be amplified by the gain of the preamp!

The reason is relatively simple to understand if you look at the situation from a noise point of view rather than a signal (S-meter) standpoint. Let's say your super-hot preamp has a gain factor of 20 dB. *That* is a *lot* of gain! The noise figure is the amount of noise generated internally inside the preamp, and must be factored into the entire equation. Normally, in today's world, the NF of a preamp is around .8 to 3.0 dB, depending upon manufacturer, circuit layout, and the solid-state devices employed. What this means is that along with 20 dB of gain, the preamp will inject between .8 and 3.0 dB of noise into the system. A normal set of ears can hear a 1-dB change. While it might be hard to distinguish a noise increase of .8 dB, most people can hear a 3.0-dB change. Therefore, you may be able to actually hear a change in background noise when you switch in the preamp.

By placing the preamp at or near the antenna feed point (these are called "mast head preamps"), you can keep the overall system noise in check *and* provide gain at the same time. The gain of the preamp is secondary to the NF. If you are going to sacrifice anything, sacrifice the gain in favor of noise. In other words, drop a few dB of signal gain in favor of a decreased NF. This will allow you to hear the weaker stations and not cover them up with the system noise of your station.

Having said all of this, I did some research into the IC-202. Looking over many internet sites, it became apparent that the actual NF of the IC-202 receiver varied considerably among units, being measured anywhere from 4 to 8 dB! What this means is that the receiver itself injects between 4 and 8 dB of noise in on top of any signal that is being heard! Why the huge disparity? Darned if I know, but a good guess might be traced to the variations in manufacturing techniques used in the solid-state RF devices of that period (late '70s through mid-80s).

In talking with Zack Lau, W1VT, from the ARRL Lab, I was enlightened. Zack had a different take on the IC-202 and any associated modifications I was planning on implementing to improve the NF of the receiver. Zack's comment was "Why? The radio is a 25+-year-old rig, with associated technology of the day. Things have changed over the years, including unbelievable crowding of the VHF+ bands, which would basically negate any efforts to improve the IC-202 receiver." Good point, Zack.

However, being a long-time QRPer, ardent homebrewer, and zealous tinkerer, I just couldn't resist the idea of performing a couple of the more simple mods to improve the IC-202 receiver. As detailed last month, the mods involved rewiring the input to the receiver to exclude the transmitter pi-network output filter, which resulted in approximately 2 dB improvement in NF, and replacing the existing 3SK40 MOSFET in the first mixer with an updated quieter GAsFET device (Philips BF-981). According to published information, I gained about another 2 dB of NF improvement using the BF-981 device. I am well pleased with the receiver mods on the IC-202, and overall I noticed a significant improvement in receiver sensitivity by doing them.

Since I also have an unmodified IC-202, I can do "A-B" comparisons between the two receivers. There is a definite increase in receiver performance on the modified IC-202. Quite frankly, I preferred this tack rather than placing a wideband RF preamp (with its associated increase in NF) into the receive antenna line. Besides, I didn't really think I needed an additional 20 dB of raw gain. Sometimes you have to know when to leave things well enough alone.

Thick as a Brick

Among the many things one can acquire (at moderate cost) at hamfest fleamarkets is a "brick" amplifier. They get the "brick" pseudonym since these power amps are normally a compact solid-state amp with an extremely large heat sink attached. The shape and weight equate to a "brick." Now you know!

Normally these amps take 2 to 15 watts input and yield somewhere between 10 and 85 watts output on your favorite VHF+ band. Recently, I procured an old Tokyo Hy-Power 85-watt linear (CW/SSB) power amp that featured a 15-dB receiver preamp. Total cost $20! I really didn't expect the amp to work, especially at that price. However, after firing it up on the bench I was rewarded with about 10 watts output on 2 meters while driving the amp with the IC-202 in the CW mode running about 1.5 to 2 watts key-down output. Hmmm . . . that was about right! The receiver preamp worked, too, so I was really ahead of the power curve on this particular purchase! Twenty bucks for an 8-watt increase in RF output (about 7 dB of gain)—not bad! Of course, if I ever find the 10-watt, 2-meter amp that matches the IC-202, I can then daisy chain the two amps and get about 75 to 80 watts output on 2 meters! Then we'd be cookin'!

This amp came in quite handy during Field Day 2005 with the Eastern Pennsylvania QRP club at French Creek State Park, near Reading, Pennsylvania. On a couple of occasions it actually made the difference between working the target station and a missed QSO. Since this was a QRP effort, the addition of the amplifier and the associated 10 watts of output power (on SSB) still qualified this station for the QRP category.

During Field Day 2005 my wife, The Beautiful and Talented Patricia, KB3MCT, made her first contacts on 2 meters! Trooper that she is, she stood her watch at the VHF+ station at French Creek State Park and added a few Qs to the total contacts. Life at VHF+ during Field Day is not all that exciting due to the majority of emphasis being placed on HF operation. However, it does have its moments!

Thanks to the efforts of a very helpful local ham, Phil Theis, K3TUF, we were able to check out and verify the operation of a new 4-element, dual-band (2 meters and 70 cm) log periodic array (LPA) designed for portable/rover use. The neat thing about this antenna is that it collapses down into a very small package for transport. This is great for VHF+ ops who want to do some serious hilltopping or portable work. The Radio Web Store (http://www.k1cra.com) sells the DK9SQ portable log periodic 2-meter/70-cm beam (model #KANG0002).

While four elements don't sound all that impressive on VHF/UHF, the portability aspect of this antenna far outweighs the shortage of elements. Pat and I used this antenna exclusively on 70 cm. Pointing the antenna directly at K3TUF's QTH yielded an S-9 + 20 dB incoming signal on the IC-402's receiver.

It should be clarified at this point that the IC-402 was a completely stock receiver with no internal modifications or external receiver preamplification. Turning the small LPA around 180 degrees dropped the S-meter down to an S-9, indicating an approximate 20-dB loss of signal strength. Okay, so we crudely measured the front-to-back ratio of this antenna at 20 dB. As we turned the LPA broadside to K3TUF's QTH, the S-meter dropped off to around S-5; roughly a 32-dB loss of signal. Not bad for a front-to-side ratio.

Indications are that this tiny transportable dual-band LPA performs quite nicely for a price of around $85 and is well worth exploring for anyone needing a small antenna for hiking, camping, hilltopping, and/or roving. My most humble thanks to Phil Theis, K3TUF, who took the extra time during Field Day to help sort out the dual-band LPA. This is what ham radio is all about.

In the next column we will be taking a critical look at antennas for VHF+. Keeping with our overall theme of "doing more with less," cost will, of course, play a major factor in what we erect. Until next time, stay focused, look for bargains, and spend some time in front of the radio! ■

By Bob Witte,* KØNR

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

FM Simplex on the Road

This summer I did two road trips, over 1200 miles long, across the Midwest from Colorado to Indiana either via Interstate 70 or 80. I like road trips and always make sure I have something interesting to do with the ham gear while traveling. I've tried different types of radio activity during similar trips, including working a VHF contest as a rover, working HF mobile, and working the FM repeaters along the way.

A VHF/UHF transceiver set up for dual receive on the 2-meter band, with one 2 receiver set to 146.52 MHz.

Repeaters are useful on a road trip, but I have to admit that sometimes I get tired of dialing around trying to find the right frequency and CTCSS while mobiling down the highway. I've noticed that simplex contacts can be especially enjoyable, since you tend to work other hams out doing their own road trips. It is almost like DX in reverse. Normally we think of DX stations as people from far away brought to us via the magic of radio. Two-meter FM mobile simplex is just the opposite—people close by who may have come a long way via their automobile travels. It is fun to make random contacts and find out where people are from, where they are heading, and their interests in ham radio.

With that as background, I want to encourage everyone to try 2-meter FM simplex when out on the road. Here are a few tips for making this work better:

Tip 1. Monitor 146.52 MHz

Okay, so maybe this is an obvious one. However, did I hear someone suggest that we need an official 2-meter FM Road Frequency? Well, we have it. It is 146.52 MHz, the National Simplex Calling Frequency, per the ARRL 2-meter band plan. This frequency is commonly referred to as "Five Two." It is the frequency to use when you are cruising the Interstate. (I am going to intentionally sidestep the issue of ragchewing on .52 for now—maybe later, maybe never.)

I am *not* proposing that you stop using repeaters, just that you make it a point to monitor .52 in addition to listening to the local repeaters. This leads to our next tip.

Tip 2. Use a Dualband/ Dual-Receive Transceiver

It is really helpful to have a dualband transceiver that can receive two frequencies simultaneously. These rigs have two separate receive systems that usually default to having one on the VHF band and the other on the UHF band. Most (but not all) of these rigs allow you to program the receivers independently for either band. To enable efficient 146.52 monitoring, just keep one receiver on 146.52 and set the other one to any other frequency of interest (e.g., the nearest repeater). This is sometimes referred to as "V/V" or "VHF/VHF" operation. Examples of current ham transceivers of this type are the ICOM IC-2720H, Kenwood TM-D700A, and Yaesu FT-8800R. I've assumed that you'll want to have both receivers on 2 meters, which is probably the case when you are in less-populated areas. However, you might choose to listen to a UHF frequency, either a repeater frequency or the UHF FM calling frequency, 446.0 MHz. On many rigs you can even scan a set of frequencies stored in memory on one receiver while monitoring .52 on the other receiver.

Single-band 2-meter FM rigs and many of the lower cost dualband rigs can only receive one frequency at a time, so check out the data sheet carefully. If you don't have dual-receive capability, you may be able to use some other radio features to monitor .52. You can put 146.52 in memory and scan it along with the other stored frequencies, or use the "Dual Watch" or "Priority Channel" feature to scan two frequencies (with one of them being 52). Any way you can, keep an ear on "Five Two."

Tip 3. Call CQ Frequently

Now that we have everyone listening on .52, we need to make sure that someone is calling! It is easy to run many miles down the road without hearing anything.

Let's do some math on two mobiles approaching one another out on the highway. Let's assume that the mobile-to-mobile range on 2-meter FM is 20 miles and that the speed of both mobiles is 60 miles per hour. Sure, you might be going faster than this, but 60 miles per hour makes the math easy, as that speed equals one mile per minute. The two mobiles will just be able to make contact when they are 20 miles apart. Since they both will travel 10 miles in 10 minutes, 10 minutes later they will pass one another on the highway. Another 10 minutes later and they will have traveled another 10 miles and be just out of range. The net result is that they have a 20-minute window to make a contact.

I made some assumptions that might be optimistic. If the maximum range of the mobiles is only 10 or 15 miles, or if they

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Hurricane Katrina

Just before press time, Hurricane Katrina had hit the Gulf states and the emergency response was underway. I am sure more complete coverage will become available over time, but here are some early observations, with an FM VHF emphasis.

Be Prepared

Hurricane Katrina, like most major disasters, reminds us that it pays to be prepared. Fixing that antenna cable you've been neglecting, replacing that dead battery pack, or finishing that half-done mobile installation as an emergency unfolds is not the best approach. Get it done now.

We also need to prepare ourselves in terms of training. The communications from the ARRL concerning Katrina emphasize the value of having completed at least Level I of the Amateur Radio Emergency Communications (AREC) course training. This is an important credential to have if you volunteer to help in a geographic area away from your home. The Section Emergency Coordinators in affected states are likely to have many hams with a range of experience and skill volunteer. The AREC training does not guarantee proficiency, but it indicates you've spent time and energy on training for emergencies. If you haven't passed this course, it is time to get it done.

Keep in mind that a disaster situation is inherently chaotic. (If they were completely planned, we wouldn't call them disasters.) It is vitally important that hams responding to the need for radio communications coordinate with the appropriate ARES or RACES officials to ensure that they are part of the solution and not aggravating the problem. Of course, you should already be involved with your local ARES or RACES team.

Media Coverage

We always need to look for ways for the general public to know about and appreciate the role that ham radio plays during emergencies. Sometimes we are involved with important public-service work that gets no attention. Sure, the served agency may know that we are there making a difference, but the general public may not see it.

With Hurricane Katrina, I am jazzed that the mainstream media has picked up and is telling the story of the ham radio response. I did a search on the web and found dozens of stories in the media about ham radio activity, including handling health and welfare traffic as well as handling life-saving communications.

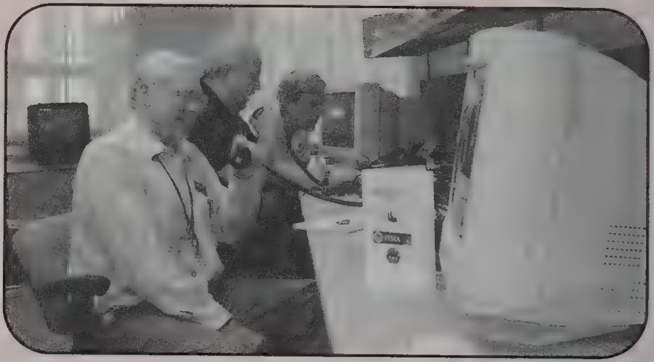
Of particular note is an interview with Ben Joplin, WB5VST, on the NPR program *All Things Considered.* Ben did a great job of describing the role of ham radio in a particular rescue effort after Katrina hit, in a way that was understandable by the general public. Sometimes hams get wrapped up in talking about their station, the frequencies used, the propagation effects, etc., and lose the main story. Ben's message was concise and on target for the general audience. This interview is online at: <http://www.npr.org/templates/story/story.php?storyId=4824598>.

The Role of VHF FM

The fundamental communications challenge in a disaster situation results from the breakdown of infrastructure: the telephone system, mobile/cell-phone systems, police/ fire communication systems, electric utilities, water systems, etc. These systems often are either damaged in the disaster or they are overloaded by the increased load resulting from the disaster.

Unlike many communications systems, ham radio is amazingly resilient. A large number of hams will be back on the air in short order, even in the face of antenna damage and loss of electric power. In addition, ham radio is very *agile*, in a number of ways. We are *frequency agile,* in that we can use any of the ham bands and any of the repeaters within the VHF/UHF bands to establish communications. Ham radio is *location agile,* in that our stations can be moved to operate almost anywhere, with or without AC power available. Finally, a well-trained ham operator is *personally agile,* able to adapt to changing conditions. All of these things play together to enable the ham radio community to respond effectively in the case of emergency.

The early reports of Katrina were mostly about HF operations. This is typical of large-scale disasters where the outside world is trying to get in touch with the disaster area. The high-frequency bands are an incredible resource for this kind of work. Later reports included the use of the VHF/UHF bands, near the disaster and points distant.



ARES members operate from the Colorado State Emergency Operations Center (EOC) in support of Operation Safe Haven. Left to right: George Riedmuller, NØNJM; Ben Baker, KBØUBZ; and Dan Meyer, NØPUF.

VHF FM is the *utility mode* and is always a key part of emergency and disaster communications. The ham infrastructure, in the form of VHF and UHF repeaters, often comes into play. Of course, these repeaters can be knocked off the air by storms or other events, but in most cases there are machines still on the air after a storm. Many ARES groups maintain a portable repeater that can be called into service if repeater coverage is lacking (location agile). Depending on terrain, simplex communications are very useful, eliminating the need for repeater coverage.

A key advantage of VHF/UHF FM transceivers is that they are very compact and portable (location agile*),* especially handheld radios. Antennas are small, enabling VHF/ UHF operations to be set up quickly in a variety of situations. If you are a reader of *CQ VHF,* you probably have a rig that operates VHF FM. These radios are very affordable these days, with 2-meter FM mobile rig prices starting at around $150. UHF (440 MHz) capability is becoming more important as ARES/RACES groups make use of that band. (Check with your local emergency communications group to find out what they recommend.) Fortunately, dual-band radios are also affordable, starting at around $250 for a radio that covers 2 meters and 70 cm.

Operation Safe Haven

As I write this, people from New Orleans are being evacuated to the Denver area. Dormitories at the Colorado Community College, Lowry Campus (former Lowry Air Force Base) are being used to house the evacuees. According to the *Denver Post,* Operation Safe Haven will transport up to one-thousand refugees to Buckley Air Force Base and then by bus to Lowry, where they will be housed in 500 dorm rooms.

Communications support for this effort is being provided by multiple ARES groups, with Arapaho County ARES taking the lead. This is a classic VHF FM utility-mode communications operation, making use of several VHF/UHF repeaters, including the Rocky Mountain Radio League 449.450-MHz machine, the 146.88-MHz Denver Radio League repeater, and the 146.805-MHz WA2YZT repeater. While not in the heart of the disaster area, this is an important support operation to provide housing for people evacuated from the disaster area.

Disaster Response Team

The Colorado ARES/RACES Disaster Response Team has been called into service at the request of the ARRL Section Manager in Louisiana. As of September 9th, they are heading to the city of Covington, LA to support EOC and Red Cross operations. This team was created with this kind of response to another geography in mind. Team members are Mike Allen, NØMIK; Tom Dawson, KCØNRZ; Dean Haskins, KAØPII; Paul Garvey, KCØMIR; and Wes Wilson, KØHBZ. Good luck, guys.

I've used examples from my own state, but I know that many other hams across the country are doing similar work. It is a good day for volunteerism and ham radio.

are traveling faster than 60 miles per hour, the time window will be correspondingly shorter. At 75 miles per hour and a range of 10 miles, the window decreases to 8 minutes. (This is shorter than a good LEO satellite pass!) It is no wonder that we often miss contacts on 146.52 MHz.

Yes, it *is* okay to call CQ on 2-meter FM. The really long CQs heard on HF are not usually welcome, but something like "CQ Five Two, this is Kilo Zero November Romeo, westbound on Interstate 70" should work fine.

Tip 4. Make your Callsign Visible

Sometimes another ham will pass you on the road and notice your mobile antenna. He or she may be left wondering whether that was really a ham antenna or just some other wireless device. Remove any doubt by making sure your call letters are visible on the vehicle. Call-letter license plates are one obvious way of doing that, but there are other ways to display your call. Magnetic stick-on signs are available online from various ham radio vendors or can be obtained from your local office-supply store. I have a small magnetic sign that just says "146.52" that I put on my bumper near my call-letter plates. It generates calls.

Tip 5. Use APRS on Voice Alert

APRS is one of my favorite road-trip modes, using a separate 2-meter rig and antenna so that it does not conflict with my VHF FM voice operation. My status message is usually configured to say, "Listening on 146.52 MHz" to encourage any APRS operators to call me there. APRS stations are configured to "ping" digital packets on 144.390 MHz, at a time interval determined by the operator.

When mobile, I usually configure APRS to ping every 5 minutes.

Bob Bruninga, WB4APR, suggests an enhancement to mobile APRS called "Voice Alert." The basic idea is that mobile APRS stations looking for simplex contacts configure their APRS transmitter with 100-Hz CTCSS enabled. Any other operators (whether they have APRS or not) listen on 144.390 MHz with 100-Hz CTCSS squelch enabled. That way they hear the "I want a simplex contact" packets that have 100-Hz tone but not all of the other APRS packets. Of course, it is important that digipeaters and unattended APRS stations *don't* transmit 100 Hz.

With this system you cruise down the highway until you hear a packet burping through on 144.390 MHz (on your CTCSS squelched receiver). Then you give a quick call on FM voice on 144.390 MHz (with 100 Hz) asking who is there on "Voice Alert." After you make contact on 144.390 MHz, you must change frequencies to a vacant simplex channel to avoid lots of interference with APRS packets. It is a clever, back-door method to use the "pinging" nature of APRS to have mobiles find one another on simplex. Pretty cool, huh?

Other Ideas

A recent e-mail from Mike Urich, KA5CVH, presented an interesting idea on how to generate activity on 146.52 MHz while mobile. His e-mail was actually to Gary Pearce, KN4AQ (former FM VHF columnist), who forwarded it on to me with comments.

From Mike Urich <mike@ka5cvh.com>:

I just made a business trip to MX last week and grabbed my Winter 2005 *CQ VHF* to reread. Based upon your comments about APRS mobile, I have something to throw to you to consider throwing to the readers. First a little history.

I have a FT-8900 in the car, which is 15 months and 72,000 miles old, so yeah, I get a lot of windshield time. I have every possible standard 2-meter pair programmed starting with 145.11 and going in order through 147.39 for both the 15-kHz and 20-kHz splits.

Obviously, I don't program the common ones twice. In the next group I have all the 442-MHz splits (442.000–442.975) then the 443- and 444-MHz splits. I have a lot of 6-meter repeaters and 52.525 programmed as well. What I do is put the right receiver on 146.52 and scan the memories with the left receiver.

Like you, I seldom make many .52 contacts, mainly because I'm not CQing, nor is anyone else when I know there are a lot of people who monitor .52 on the highway at least here in Texas. Your article triggered my thought process to look into building/buying a MCW [modulated CW] IDer to put onto my rig so that, say, every 3 minutes or so it will send out an MCW ID with my callsign. Not everyone can copy the CW, but they will hear the ID and possibly call QRZ. —*Mike, KA5CVH*

Gary's reply:

It's an interesting idea. A variation that comes to mind is you could use a "voice keyer" instead of Morse to catch everyone,

This mobile ham station, spotted in a hamfest parking lot, obviously is set up for monitoring lots of frequencies on road trips.

not just those who know CW (and not be confused with a repeater ID). Then maybe manufacturers could be convinced to include the recorder as a feature (we need more features!). Finally, we convince hams to leave it on .52 when they're on the road.

This might discourage home stations from monitoring .52 though, with a lot of IDing going on all day. Might be some brief interference to ongoing communication unless a "hold-off" feature were incorporated.

However, impromptu on-the-road contacts on .52 have always been interesting, especially if I hook up with someone going my way for a while. *—73, Gary, KN4AQ*

My thoughts are that Mike's IDer idea is interesting, especially if it were implemented to not "ping" until the frequency had gone quiet for some period of time (probably a few minutes). A CW ID would clearly have its limits of who could copy it these days and might easily be confused with a repeater output. This would argue for a voice-keyer approach. Surely this approach could be abused if people just indiscriminately banged away with voice or CW beacons on 146.52. However, for the long road trip scenario it could really be useful.

Its pinging nature is similar to Voice Alert on APRS, which apparently got Mike thinking about this in the first place. I wonder about an even better merging of these two approaches. Why can't we have a system that merges voice and data, automatically pings with digital content, and instantly enables voice communication as well? Let me know what *you* think.

73, Bob, KØNR

References

Bob Bruninga, WB4APR, APRS web page: <http://web.usna.navy.mil/~bruninga/aprs.html>.

Ham Stuff by W7NN (source for magnetic signs): <http://www.hamstuff.com/>

The Sign Man of Baton Rouge (source for magnetic signs): <http://www.thesignman.com/>

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

PCSAT2, SSETI Express, SuitSat & SSTV for the ISS

Since the last column, PCSAT2 has been carried up to the ISS (International Space Station) by mission STS-114 of the Space Shuttle and installed during a space walk (EVA); the launch of SSETI (the Student Space Exploration and Technology Initiative) had been delayed at least six months; and the 2005 Space Symposium due to be held in Lafayette, Louisiana was canceled because of Hurricane Katrina. Also, get ready for SuitSat and ISS SSTV!

PCSAT2

Launch: PCSAT2 was carried into orbit by the Space Shuttle on its return to service mission, STS-114. A few days later, 3 August 2005, it was installed on the external structure of the ISS during EVA (Extra Vehicular Activity). It has been operational since that time. Since it is physically attached to the ISS, tracking data is the same as for the ISS, and operation must be carefully coordinated with other ISS activities to avoid interference. It is part of another experiment, and as such will be retrieved after approximately one year of use. Like the original PCSAT, this one was designed and built by Bob Bruninga, WB4APR, and his team of engineers from the US Naval Academy. Full details are available at: <http://web.usna.navy.mil/~bruninga/pcsat2.html>.

Capabilities: PCSAT2 is part of MISSE (the Materials International Space Station Experiment) and provides the following capabilities:

- A *UI-Digipeater* to help ease congestion on the currently shared ARISS PMS (packet mail system).
- A *PSK-31 Transponder* for multi-user comms to improve accessibility for schools and ARISS (Amateur Radio aboard the International Space Station) outreach programs.
- An *FM Voice Repeater* for full-duplex special ARISS or crew communications to facilitate school outreach.
- Routine *Telemetry* on the spacecraft systems.

The following frequencies are used in the various modes:

UI Digipeater: 145.825 MHz FM 1200 Baud AFS
TLM and PSK Downlink: 435.275 MHz FM 1200 AFSK or PSK-31
PSK-31 Uplink: 29.4 MHz PSK-31
Aux Downlink: 437.975 MHz FM 1200 and 9600 Baud AFSK
Voice Repeater Downlink: 437.975 MHz FM
Deployed: 3 August 2005

Operation: All modes have been checked out, and the "bird" has been operated in the PSK-31 mode for several weeks as of this writing. At press time, it is available for digipeating. Telemetry has been gathered throughout the operation and is being accumulated for study.

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Use of Satellites in Disasters

Amateur radio satellites are unique, but seldom used, communications assets in times of emergency and disaster. Their wide-area coverage and predictability make them useful for traffic similar to that handled via HF. A minimal amount of equipment is needed for the LEO "birds," but the hardware needed and the techniques for deployment and use are not well understood by the general amateur radio population.

The "store and forward" digital birds are particularly well suited for health-and-welfare traffic. Again, these digital birds are even less understood than the analog birds. For example, AO-51 was configured as a "store-and-forward" bird during the Indonesia tsunami, but little, if any, traffic was passed.

VO-52 was developed in India with emergency communications as one of its primary goals; however, little use has been made of it for that purpose. It was not launched in time for the tsunami disaster. Its use would be for "point to point" contact within a disaster area on a scheduled basis.

PCSAT2 and the other ARISS UI digipeating capabilities can be extremely useful in emergency situations. Again, the capabilities are not well understood by the general amateur radio community and disaster-preparedness people.

Emergency communications tests were conducted with some success on AO-10 and AO-13 while they were still usable. More equipment is required for these high-altitude birds, but the benefit is long-term availably of the bird. With Phase 3E and Eagle coming along, we need to once again think through how to best utilize these valuable assets in an emergency.

The amateur radio satellite community needs to put on its thinking cap and come up with how to best utilize each satellite in an emergency and "start the ball rolling."

SSETI Express

The Student Space Exploration and Technology Initiative, or SSETI, project was discussed in some detail in the last column (*CQ VHF* Summer 2005) and details will not be repeated here. At last press time, it was scheduled for launch in August 2005. Until this writing, it was scheduled for 30 September 2005 with a backup date of 1 October 2005. Today, an indefinite slip due to one of the other payloads was announced. It is anticipated that this will mean at least another month. At press time, the hardware and launch team is in Russia preparing for launch, but they now will be securing the equipment and going back home to wait.

SuitSat and SSTV for the ISS

The Suit Sat hardware to be installed in the old Russian Orlon space suit has now been transported to the ISS along with the long-awaited SSTV hardware and the school project CDs. This equipment will be installed by the new Mission 12 ISS crew, which will deploy to the ISS in early October. SuitSat will be deployed in December via an EVA. Watch the AMSAT News Service and the AMSAT and ARRL web pages for updates on

 (from page 11)

allel to the ground, and started walking the rows until the signal indicated I was within a few feet of it. I literally tripped over the package.

It was 12:30 CDT now and everyone was hot, tired, and hungry. Team 3 (Mike Hackley, KCØSGD) arrived while I was searching around the corn field. After we had recovered the near-spacecraft, Mike and I shut down everything, retrieved the flight recorder and the RAM card from the digital camera and the film from the film camera.

The digital camera looked as if it had impacted something pointy and we had to pry the RAM card out of it. The camera will have to be replaced. We then drove back toward Omaha, stopping at The Rose family restaurant in Traynor.

Things we learned and that need improvement follow:

Recovery Operations: The ground tracking equipment in the chase vehicles needs to be "hardened" and tested.

We need to practice more as a team. When the teams become separated, common frequencies and contact procedures need to be used.

Standard DFing procedures need to be documented and practiced.

Several other "standards" need to be discussed, simple things such as what notation should everyone use for latitude/longitude?"

Flight Operations: An additional crew is needed for coordination of the flight phase, from launch to just after burst.

When we launch a package for a group or specific science or instrument package (e.g., the 2-meter simplex repeater), a person dedicated to controlling the package needs to be on the team. For example, the 2-meter simplex repeater was enabling contacts in Champaign, Illinois and Independence, Missouri, but there was no one to log the traffic.

Launch Operations: This went pretty smoothly except that while we had decided to use more lift that we normally would, we used too much. We had wanted 2.5 lbs and ended up with 3.8 lbs. We need to add a checklist for the launch vehicle (balloon) similar to the payload power-up and attachment checklist.

While we want to encourage visitors and participants, there is a time when it would be very useful to have a "sterile" launch area (this is also a safety issue). Stanchions and tape or orange rope might work.

Engineering: The CAPSTAR-1A near-space frame is nearing its end of life. It's getting pretty beat up. Another one or two frames need to be built and readied to fly.

The RF crosstalk between the ELT and the 2-meter FM RF sections needs to be addressed.

A commanded cut-down device needs to be installed so that we can fly larger payloads.

GPSL Suggestion

GPSL-2005 was *great!* Mark Conner, N9XTN, did a super job pulling it all together. The conference topics and speakers were *very* interesting and informative. There were ten balloons launched and over 65 people attended. It was great to work with everyone I'd met last year and to meet new groups.

I did hear a good suggestion that at the next GPSL there be a "net control station and operator." The controller's job wouldn't necessarily be to coordinate a net (there was very little congestion on the local repeater). However, the controller "could" facilitate communication between different groups when, for example, a group needs help with recovery operations or they want to cross-check their own tracking with another group. ■

both of these items. The SuitSat project will be of great interest to school kids (and older kids as well).

AMSAT Space Symposium Cancelled

The 2005 AMSAT Space Symposium and Annual Meeting scheduled for 7–9 October in Lafayette, Lousiana, reluctantly has been cancelled by the AMSAT Board of Directors. The action was taken after a careful review of the damage caused by Hurricane Katrina (and later Hurricane Rita) indicated that there was too much uncertainty in the hotel situation in Lafayette. Even though several offers were made, there was insufficient time to coordinate and move the entire meeting to a new location, and a change in date was not practical due to vacation scheduling of the attendees. The 2006 AMSAT Space Symposium and Annual Meeting will be held in the San Francisco Bay area in October. Planning has now started for that conference.

The AMSAT Board of Directors Meeting, the AMSAT Annual Meeting, and the Project Eagle Meeting were scheduled to be held in conjunction with the Space Symposium. They will instead be held on 6–9 October in Pittsburgh, Pennsylvania.

I will be attending the meetings in Pittsburgh and will report on them in the next column. The meetings should be very good with a lot of topics to discuss and some new and some renewed AMSAT BoD members attending. Incumbents reelected are Rick Hambly, W2GPS; Barry Baines, WD4ASW; and Gunther Meisse, W8GSM. New to the board is Emily Clarke, WØEEC. First Alternate is Bob McGwier, N4HY, and Second Alternate is Lee McLamb, KU4OS. Returning BoD members for their second year are Tom Clark, W3IWI; Paul Shuch, N6TX; and Lou McFadin, W5DID.

Summary

As of this writing, we now have another new satellite, PCSAT2, with a second one, SSETI Express, on the way before this fall. Sharpen up your disaster communication skills and plan to use the unique capabilities offered by the amateur radio satellites. Get ready to fully utilize SuitSat and ARISS SSTV from the ISS. Finally, start planning now to attend the 2006 AMSAT Space Symposium in the San Francisco Bay area.

73, Keith, W5IU

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

Transmit-Receive Relay Control Switching Circuit

This time we will discuss a simple sequencing relay-control switching circuit that I have used for some time. Although the circuit is simple, it controls two 12-volt relays that are the heart of the device. Activation of the switching is done by PTT (push to talk) RF detection from a 2-meter multimode low-power (modified) IF driver. In this case, RF output power is reduced from the normal low-power setting by modification of the 2-meter multimode radio to obtain RF power in the 100- to 200-mw range. An additional relay can be installed to further reduce the power to the desired level by insertion of a relay to add a pad of 3 to 10 dBm in the coax path before it is injected into the mixer circuit of the microwave converter. The idea here is to keep power low to protect the 10-GHz mixer, as it is a precious device and difficult to obtain. All efforts are made to keep RF transmit power low in the IF converter stages of the microwave converter to protect the mixer.

Additional protection is provided by the circuit's two relays, which are sequence driven by the N-channel FETs and the switching time constant that controls each one of them. Contacts on these two relays are used to control the coaxial relays and associated receive and transmit amplifier components of the microwave converter. When the PTT switch is depressed, it causes the receiving pre-amplifier circuits to be switched out before the transmit amp control circuitry is switched on. The opposite is done by releasing the relay circuitry. When the IF transmit PTT is released, the transmit relay circuitry is fast to release and the receive preamp control switching is slow to release. This is accomplished by using two different time constants in this circuit. They are 1 mFd charged by a 1K-ohm resistor and 1 mFd charged by a 47K-ohm resistor. Charging or discharging a 1-mFd capacitor through a 1K-ohm resistor is fast compared with charging through a 47K-ohm resistor.

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Capacitor values can be changed to add or remove capacitance to suit your specific timing requirements. I set up a couple of LEDs tied to the drains of each FET with a series 1.3K-ohm resistor to +12 VDC for the LEDs' DC power. In this way I could watch the timing of the "A" and "B" relay drivers by observing the LEDs for visual circuit timing of the "A" and "B" relay controls. Relays could have been used here just as well, watching the time each relay operates and releases.

These two relays are controlled by a simple diode control circuit switching two different time constants. The use of DC relays provides isolated contacts that can be wired to switch your coaxial relays and associated amplifier circuitry for receive and transmit control. This simple diode steering circuit protects the receiver preamp by switching the coaxial relays on the receiving side of the circuit, taking the preamp out of the circuit before the transmitter amplifier coaxial relays are switched in. Just the opposite is done when the transmit relays are switched out (released) first, and then the receiver relays are switched back in the circuit.

It uses a simple diode switching circuit that controls the DC distribution to several time-constant circuits via diode steering, producing a fast-to-operate and slow-to-release receive time constant for the (A) sequencing relay, receiver-controlled switching. The sequencing for transmit RF amplifier relays is controlled by the (B) relay circuitry, and the time constant is just the opposite. The time constant is slow to operate and fast to release.

Operation is as follows: When the IF transceiver (100-mw driver) PTT microphone switch is operated in transmit, the 741 op-amp detects RF input and the 741 goes high with +12 VDC output and charges the 1-mFd capacitor (discharged by a 1-meg resistor), controlling hang-time operation of the circuit. Increase the 1-mFd capacitor and the circuit will stay operational longer after the PTT is released. The first gate of the 4049 IC (plus in pin #3; low out pin #2) causes the "A" relay FET to operate by charging a 1-mFd capacitor through a 1K-ohm resistor. Fast to operate and slow to release (PTT released) occur by discharging the "A" relay 1-mFd capacitor control through a 47K-ohm resistor.

The diodes used in this control circuit are 1N4148 because they were in the junk box. They also are easy to obtain surplus. Anything similar can be used; it's just a low-power signal diode. The 741 op-amp and 4049 hex inverter are also easy to obtain. The Buz-72 is an N-channel FET and can be replaced with a NTE66 high-speed switch TO-220 package. I used the Buz-72 because it was in my junk box.

Due to the fact that we reduced the RF power output to 100 mw, a sensitive detection circuit was needed to start off the circuit operation and then remain reliable. Standard RF detection circuits using Darlington transistors to detect the RF transmitter power (100 mw) just did not work well at this low power level.

The RF drive, now in the 100- to 200-mw range, from a modified 2-meter rig used for converter operation needed an RF detection circuit that would detect the IF-system PTT in transmit SSB mode. I wanted the circuit to activate with background noise when the PTT switch was activated on the IF-driver multimode 2-meter transceiver.

I found a promising circuit to modify, dropped the output circuit, and kept only the detector rectifier and amplifier parts of the circuit. What was used was a double-diode RF detection rectifier coupled to a 741 op-amp that produced sufficient gain for low-level PTT operation for SSB before modulation was applied. The finished circuit was very sensitive in detecting operation of the transmitter low-level PTT operation. I used a coax line passing through the transceiver switch and coupled a 5-pF capacitor to tap off some of the RF between the coax center conductor and the switch detect rectifier. With 100 to 200 mw passing through, this amount of coupling has proven to be adequate. I assembled the unit and constructed the circuit dead-bug style on a small piece of copper circuit board. Kerry, N6IZW, designed the diode-switching second half of the switch timing control circuit. It is

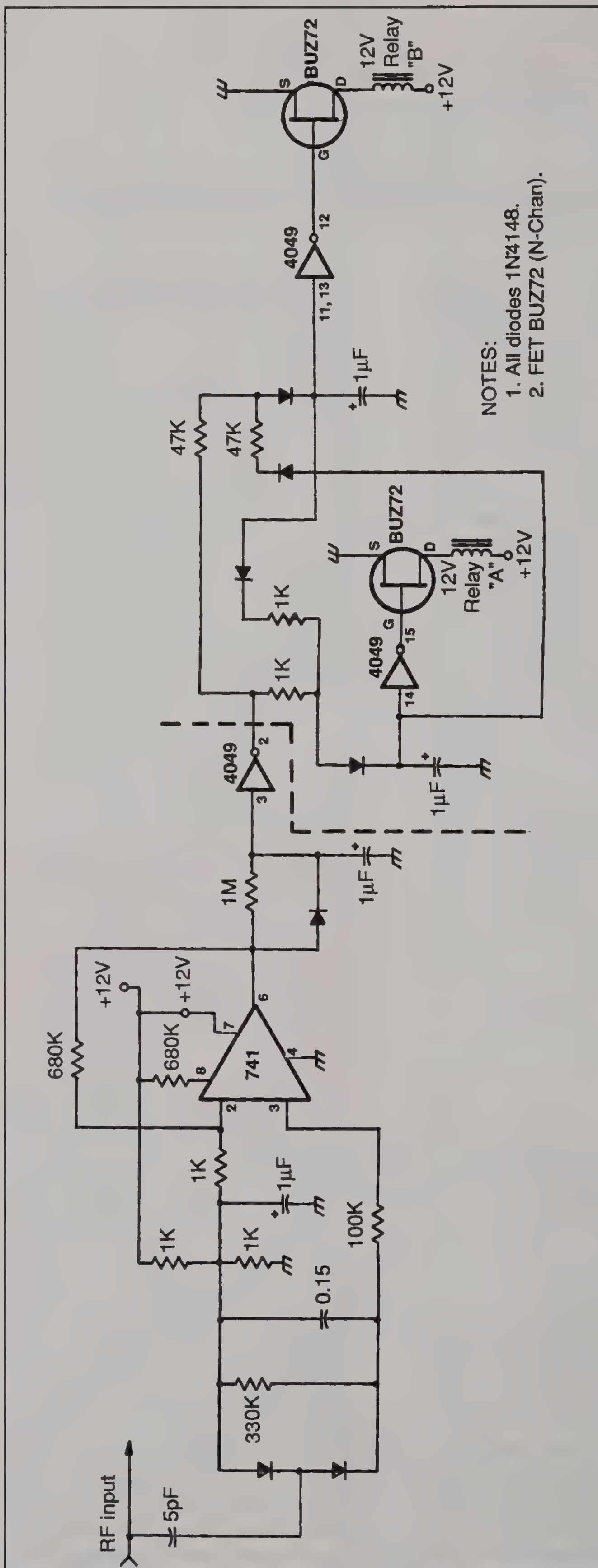

Figure 1. Schematic diagram of the sequenced switching relay control circuit.

quite innovative. Without Kerry's circuit design and his help, this project would not have been completed.

Reliability

This circuit is still in service on my 10-GHz main transceiver. What has helped over the years is that I potted the dead-bug parts in a layer of RTV, which has held up well. By having lots of relay contacts available, many different configurations can be used to suit your switching requirements. For instance, I switch in an extra drive amp for the TWT (traveling wave tube) and remove connectivity to the low-noise pre amp with this circuit. On transmit I also switch on and off a 10-watt TWT with the setup of four SMA coaxial relays to control all the switched functions. This setup has been in operation since the early 1990s.

I should reconstruct the circuitry and clean up the many experiments and changes that were made to my 10-watt black box rig for 10 GHz over the years of operation. I call it my "black box" rig, as it is housed in an old BC221 WW II military surplus frequency-meter case. Yes, I might have been just lucky, as the circuit and the 10-GHz rig it controls have performed well over many years of operation. However, I feel that taking these additional protection methods has contributed substantially to the success of the rig's operation over the many years of use. It has survived the grandchildren and their nearby sand box, and many nights in the rain.

There are many different types of controllers that are more complex than the device described here. However, as I stated in the beginning, this was to be a simple device—easy to troubleshoot and use, easy to construct using standard parts, and easy to put together with a low parts count for the entire circuit. I might point out that this switch controller can be used on other converters for PTT switch operation. It's not band specific on 10 GHz. By detection of RF external to a modified low-power IF driver, many different rigs can be adapted to one standard PTT RF switching circuit.

With low-power operation from the IF rig, using its internal microphone controller, a variety of IF driver rigs for this switch-controlled transceiver circuit are possiible. I have used this board in 1296-MHz converters and for 3456 MHz and 5760 MHz—plus 10 GHz, where this project started. Switching of the PTT operation has proven to be a great asset in communications.

I have a few PC boards of the home-constructed type that are available on a limited basis. I am looking at trying to get better artwork done and boards produced later. However, the circuit is not that complex, and a dead-bug wiring job like I originally did can be just as effective as fabricating a PC board. I just retired from 43 years of service working for the Bell System and later SBC Communications, so time to play with projects is not a factor for me. If there are any questions regarding this project, just drop me an e-mail at <clhough@pacbell.net> and I will reply as quickly as I can.

New projects on the work bench include a 1152-MHz synthesizer used for a marker generator, along with a second 2-GHz synthesizer. The second synthesizer on the PC board can be programmed for 2556 MHz, which is an LO (local oscillator) injection frequency for 10368 MHz (2556 MHz × 4 + 144 MHz = 10368 MHz). The board is up and running. However, documentation on the modifications is needed to make the board useful as a marker for most of the microwave band bottom edge, which is a multiple of 1152 MHz. For instance, 5 × 1152 MHz is 5760 MHz, and 1152 MHz × 9 is 10368 MHz, making the board and its harmonics quite useful and improving accuracy as a band-edge marker or LO for 10368 MHz. 73, Chuck, WB6IGP

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Practice Makes Proficiency: Learn RDF and Have Fun

You have probably heard the old joke about the musician standing in front of a New York hotel with his instrument case. A passer-by asks, "How do you get to Carnegie Hall?" The musician answers, "Practice!"

As I write this, hams from around the country, including some from here in southern California, are helping victims and agencies in the wake of hurricanes Katrina and Rita. No doubt each of them is thankful for the preparedness that prior drills and training have provided.

Are radio direction finding (RDF) skills being used by hams after the hurricane? My guess is they are, and I'm eager to get any such reports. I know that transmitter hunters have served the public in disasters near me, as the following example shows.

McKenzi Garlitz, KE7DRD, of West Jordan, Utah is excited after finding her first hidden transmitter at the beginner's hunt of the Utah Hamfest. (All photos by Joe Moell KØOV)

De-jamming the Sheriff

In 1994, JaMi Smith, KK6CU, was a District Communications Officer for the Los Angeles Disaster Communications Service (DCS). Right after the Northridge earthquake that devastated parts of Los Angeles and vicinity in January of that year, he took charge of the RACES room at the Sheriff's Communications Center (SCC) and the county's Emergency Operations Center (EOC) in East Los Angeles. Thirteen hours after arriving, JaMi was taking a short break from his volunteer DCS duties when a county employee, also on break, mentioned that a steady carrier had appeared on a county-wide law-enforcement frequency.

At the time, KK6CU was a regular participant in mobile T-hunts. He used a unique motorized VHF/UHF quad and storage oscilloscope display unit on three ham bands. However, he had traveled by motorcycle to the EOC, leaving his gear at home in Pasadena. Besides, the stuck transmitter was near 482 MHz, out of range for his UHF RDF quad. Figuring that he could hunt the carrier with a beam and his extended-range hand-held, he asked if a Yagi for 482 MHz was available. The answer was negative.

Minutes later, JaMi was approached by Larry Bryant, N6YLA, Officer in Charge at County Incident Command, along with a sergeant from the Communications Section. They told him that the interference was blocking a sheriff's administrative repeater that was vital for radio-assignment requests and quake-related mutual-aid communications. Of 37 receiver sites in the county, eight were picking up the signal. Vehicles and RDF gear were available. Could he help?

JaMi and the sergeant surveyed the SCC equipment pool, finding a commercial Watson-Watt type RDF set and antenna system by OAR Corporation (now Cubic Corporation).[1] Further search yielded a multi-mode scanner, necessary because Watson-Watt RDF processing requires an AM-mode receiver.

The RDF unit had two connectors for receiver IF input plus an audio connector. The scanner had no IF output connector and no equipment manuals were handy, so JaMi decided to try hooking just the scanner audio to the RDF set. For this he needed a cable with an RCA plug on one end and a miniature phone plug on the other. He quickly made one by cannibalizing a set of headphones and soldering its cable to a spare cable with an RCA plug.

The sergeant offered a choice of vehicles and an officer to drive. He and the radio technician strapped the RDF antenna to the car top and put the rest of the gear inside. After a quick check of the setup using a hand-held transceiver, they took off. JaMi rode with the driver in front and the technician sat in the back. The offending carrier was not copyable at the SCC, but signal levels into the receiver "voting" system led the county's technician to conclude that it was coming from the north end of the San Fernando Valley, perhaps from Sylmar.

Radio Waves and Ping-Pong Balls

UHF signals reflect from nearly any hard surface or object that's bigger than a breadbox. They carom off mountains, hills, buildings, billboards, and cars. The bearing on an RDF display tells the arrival direction of a signal, but in urban or hilly ter-

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Larry Benson, N7GY, of West Valley City, Utah put on three transmitter hunts at the Utah Hamfest.

rain this may not be the direction from which the signal originates.

When signals arrive at a receiver by both direct and reflected paths simultaneously, the effect is called "multipath." In severe multipath, an RDF bearing may change constantly, or be consistently wrong. From his T-hunting experiences, KK6CU knew that the best way to maximize the signal level and get an accurate bearing, with minimum multipath effect, is to be as high and in the clear as possible. He decided to immediately go to the top of the hills above Hollywood.

"On Mulholland Drive," he says, "there's a great spot that overlooks the San Fernando Valley. I've used it on T-hunts before. We headed up Interstate 5, then west on Highway 134 to Highway 101. All we could get was an occasional blip of signal on the RDF set. We had just gotten off 101, going south on Laurel Canyon Boulevard, when I got a strong bearing to the west as we waited at the light.

"I suspected a reflection," JaMi went on to say, "and it went away as we went south. But as we gained elevation, the signal came up again, mostly bearing to the north because it's a box canyon. The hills were to the east and west. Once we were up on Mulholland, there was a steady bearing and virtually full-quieting signal. Before, we had gotten a lot of broadband noise. I could tell that because I have learned from experience to check by tuning off frequency to see if I am hearing noise or signal.

"We had no maps and no compass, but I knew that streets in the valley run north and south, so I looked down toward them for reference. The strong bearing was about 290 degrees true, pointing toward the extreme northwestern end of the valley. The tech said he didn't believe it. He still thought it was to the north."

Back at Highway 101, the trio headed west at well above the speed limit. "A couple of miles west, we started getting signal again," JaMi explained. "Then the bearing started to change. I got a couple of strong due-north blips at the Van Nuys exit, but we still guessed we would have to go to the far end of the valley. By the time we got to Interstate 405, we were not getting good signal strength because we were below ground level. We decided to go north on the 405, and as we came up, I got good bearings east of us, swinging again. I told the driver to take the next exit. He locked up the brakes, swerved over, and we went east on Victory Boulevard."

JaMi and his companions were now only six miles from the earthquake epicenter. Power was out in most places and a curfew was in effect. Fortunately, the driver was an officer in uniform.

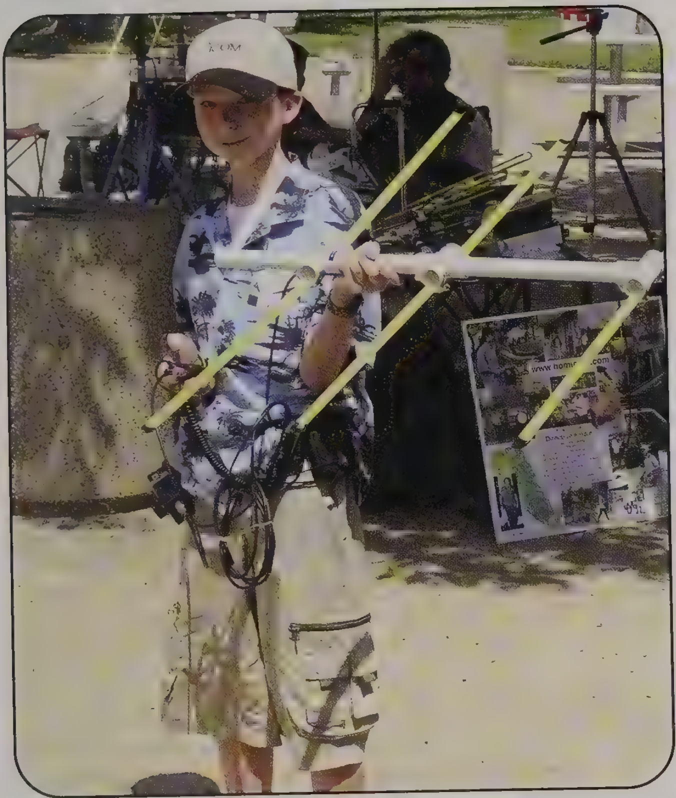
Multipath makes UHF RDF in urban areas tricky. Rows of buildings tend to funnel signals down the streets. The bearing may appear to be constantly in front (or behind), and then suddenly change at an intersection. "As we approached Van Nuys Boulevard, the bearing tended toward south," KK6CU continued. "Now the signal was full quieting and I could hear the DF tone plainly in the AM receiver audio.

"I had the driver pull out into the intersection very slowly. There was a lot of multipath and the display swung around quite a bit. I told him to continue east, and at the next street we went out in the middle again. It looked to be toward the south, so we turned that way for three blocks and found ourselves inside a large complex of government buildings, including two courthouses and the Los Angeles Police headquarters for the San Fernando Valley."

They headed for the police mobile command center, where JaMi got out and checked by the vehicles with his dual-band hand-held. No stuck mics there. Back in the sheriff's car, they drove around the complex. Signal was weak everywhere except on the south side of the Northwest District Superior Court building. They parked again and walked all around, seeing no one but noting boarded-up doors and other signs of damage.

After going next door to the police sta-

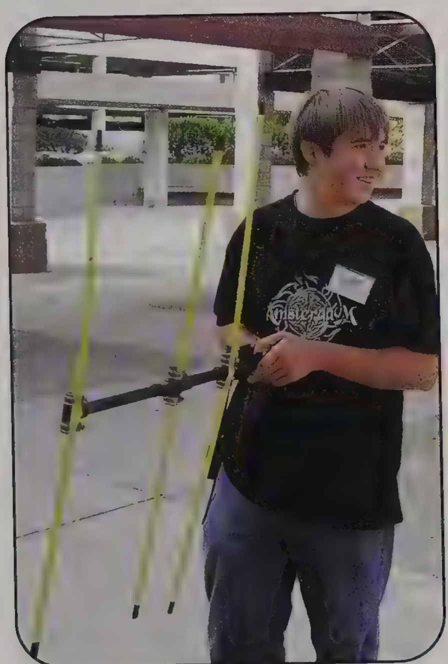
Even when moved out to the lawn, the Utah Hamfest forums were well attended. Mike Collett, K7DOU, of Layton, Utah is showing his 2-meter "shrunken quad" antenna for RDF.



At the Catalina Amateur Repeater Association picnic, Eric Rice, KG6SIH, of Northridge, California found all of my hidden transmitters after instruction from his Dad, WB6BXP.

Matt Mendenhall, KE6ALM, of Norwalk, California was first to find the SOARA transmitter at the CARA picnic. Then he and Kareem Rashad, KG6USK (not pictured), set off to find the mini-T's in the park.

tion, they introduced themselves and KK6CU checked for signal inside the building. Meanwhile, the technician found out that a sheriff's radio set had been installed in the Superior Court building a year ago. Back they went to that courthouse to peer into the windows again.



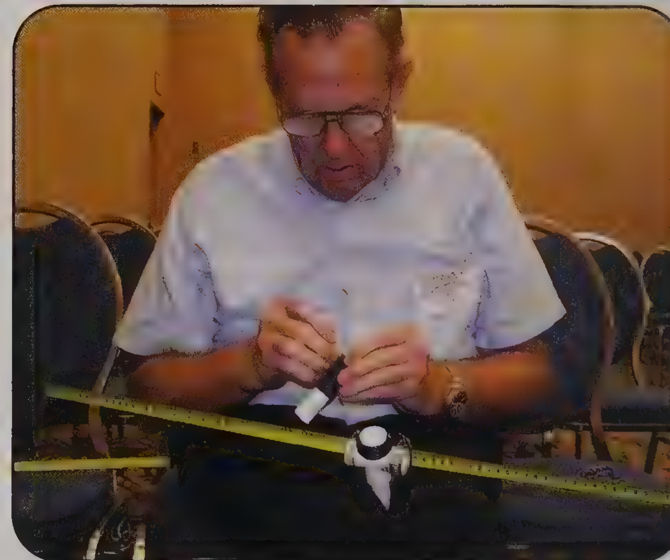
Trey Barton, KG6ZOE, of Rancho Palos Verdes, California won the 2005 ARRL Southwestern Division Convention on-foot transmitter hunt.

"Finally, we saw somebody inside," says KK6CU. "It was a plainclothes deputy assigned to guard the building. He let us in and we asked directions to the communications room. There we found wet ceilings and water all over the floor from leaking pipes. There was an old desk with stacks of paper around the edges of the desktop, which was sagging in middle. Water was a half inch deep in the center. An old desk mic sat in the middle of the pool with its pushbutton switch submerged. I carefully pulled it out, shook it dry, and the carrier disappeared!

"We were still in a period of strong aftershocks," JaMi continued. "So we decided to get out of there right away. To be safe, we unplugged it and a few other pieces of equipment that were saturated. I disassembled the RDF gear and we headed back to the SCC."

The submerged microphone was connected to a 100-watt transmitter. So why was the signal so weak until the T-hunters were within a mile of the courthouse? It turned out that this radio is used mainly for communications within the building on simplex frequencies. The transmitter drives a long run of special "leaky" coax, such as Radiax® by Andrew Corporation.[2] It goes up the south side of the

Jay Thompson, W6JAY, showed simple on-foot RDF gear to attendees of the 2005 ARRL Southwestern Division Convention and told of his travels to the ARDF World Championships. Besides his own hour-long talk, he was a speaker at the Youth Forum.



At the ARRL Southwestern Division Convention's RDF workshop, David Danner, K6AIX, of Canoga Park, California assembled a 2-meter tape-measure Yagi.

building to a dummy load. Enough signal escapes from the coax to reach the officers' transceivers inside for simplex work. The signal can also be heard by the sheriff's sensitive repeater network when the transceiver is switched to the administrative frequency, which the marshall had apparently done at the end of the last work shift before the quake.

Despite unfamiliar equipment and a weak signal, KK6CU found the problem and fixed it in less than an hour. Without JaMi's understanding of RDF principles and his practical foxhunting experience, the interference to emergency communications would have lasted much longer.

Learn and Have Fun

When an emergency is at hand, it might be too late to build RDF gear and learn to use it. Fortunately, the building and learning process can provide a great deal of enjoyment in itself. Fun, education, and emergency preparedness—what a great combination!

More and more ham groups around the country are giving amateur RDF a try. Not only are they setting aside days and evenings for mobile and on-foot transmitter hunts, but they are incorporating it into other membership activities. For instance, for several years there have been transmitters to find at the annual Catalina Amateur Repeater Association (CARA) picnic. At first, only the bravest hams tried it. Now people of all ages are joining in.

At this year's CARA picnic there were five of my foxboxes in Heritage Park. In addition, there was the hidden T for the mobile hunt of the South Orange Amateur Radio Association (SOARA), courtesy of that day's huntmaster, Dave Seroski, KG6QCI. CARA picnickers watched and joined in as cars full of SOARA hunters arrived and tried to find them all. (We told them that they couldn't get free burgers until they did!)

Along with transformer tosses and left-foot CW sending (QLF) contests, many hamfests and conventions are staging on-foot transmitter hunts. Most of them are on 2 meters, where RDF equipment can be very simple. A Yagi made from steel measuring tape, a simple RF attenuator, and a handie-talkie are usually all that it takes.[3]

In late July I had a great time at the Utah Hamfest near Bryce Canyon. An unexpected hazmat incident[4] moved my forum talk and several others out onto the lawn, but everyone stayed in good sprits. I told them about hams around the country who are traveling the world in search of ARDF medals. Mike Collett, K7DOU, and I showed them some easy-to-build RDF gear.

The Utah Hamfest Huntmaster, Larry Benson, N7GY, staged three on-foot hunts of varying difficulty on the spacious grounds of Ruby's Inn. The first had only one fox and was only a few dozen yards away, just to give everyone the idea and to help them check gear. The next day there was a two-transmitter hunt, followed later by a five-fox hunt with timing that was intended to simulate international ARDF rules.[5] With that great introduction, I hope to see Utah hams at the next USA ARDF Championships (see sidebar).

RDF was high-profile at the ARRL Southwestern Division convention in

North Carolina Hosts Next USA ARDF Championships

If you missed the chance to meet and test your skills against the USA's best on-foot transmitter hunters in Albuquerque this summer, another opportunity is coming in just a few months. The sixth annual USA Championships of Radio-Orienteering will be April 7 through 9, 2006 in Raleigh, North Carolina.

The competition gets under way on Friday afternoon with an information and safety briefing, followed on Saturday by the 2-meter hunt and on Sunday by the 80-meter hunt in William B. Umstead State Park. In addition to the ARDF competitions, there will be a picnic get-together on Saturday night and an award ceremony following the 80-meter hunt.

As always, the USA ARDF Championships are open to anyone, from beginner to expert, with or without a ham radio license. Competitors are divided into standard age/gender categories, with awards for first three places in each category.

The 2006 USA championships organizers are Charles (NZØI) and Nadia Scharlau of Chapel Hill, NC. Both have been consistent medal winners at previous USA Championships. Latest event information, rules, and registration forms are in the 2006 USA ARDF Championships website: <www.ardf.us>.

ARDF is a worldwide radiosport, regulated by committees of the International Amateur Radio Union (IARU). There are competitions in over 30 countries around the globe. Every two years one country hosts the ARDF World Championships (WCs). In 2004 they were in Brno, Czech Republic, with a 21-member group from the USA on hand. The next WCs will be on the Black Sea Coast south of Bourgas, Bulgaria from September 12 through 17, 2006.

ARDF Team USA is now forming and training for the 2006 WCs. Final team member selection takes place in summer 2006, based on performances at the 2005 USA Championships in New Mexico and the 2006 events in North Carolina. If you wish to compete in Bulgaria next year, register now for the North Carolina Championships and watch my "Homing In" website: <www.homingin.com> for the latest information on ARDF Team USA membership and travel arrangements. My site also has details of the IARU's international ARDF rules and links to local groups providing ARDF training and practice.

Joe Moell, KØOV
USA ARDF Coordinator

Riverside, California this September. In addition to separate talks on competitive ARDF by Jay Thompson, W6JAY, and myself, there were two hands-on equipment workshops organized by Marvin Johnston, KE6HTS. He brought plenty of kits for the aforementioned measuring-tape Yagis and offset attenuators. Soldering irons, sandpaper, and tools were at the ready so that attendees could complete their gear and be all set to hunt radio foxes right away. Most of them built beams for the 2-meter band, but Bob Miller, N6ZHZ, and I already had them. Thus, we scaled the dimensions and built beams for the 120-MHz aircraft communications band. Now we're ready to quickly track 121.5-MHz aircraft Emergency Locator Transmitters (ELTs) when the need occurs.

Orange Section Technical Coordinator Jim Eason, AD6IJ, put on the official transmitter hunt at the Riverside convention. A 2-meter rig in an ammunition box was concealed in bushes on the convention center grounds. Several hunters headed for it and were close within a few minutes. It was Trey Barton, KG6ZOE, who saw it, snatched the ticket, got back to the start point first, and claimed the prize. Trey is one of the Palos Verdes High School students who learned about ham radio and RDF from volunteer instructor Dan Welch, W6DFW, as I detailed in the Spring 2005 issue of *CQ VHF*.

Has your local club held a hidden transmitter hunt lately? Did you include RDF in your October Scout JOTA activities? If so, please send me a note and some photos. If not, give it a try. Besides having lots of fun and perhaps enticing some new folks into ham radio, you will be developing a skill that could be very important when intentional or unintentional interference affects communications in your town, in a disaster or not.

73, Joe, KØOV

Notes

1. <http://www.cubic.com/cda1/Prod_&_Serv/C4ISR_Prod_&_Sys/DF_Products/index.html>
2. <http://www.andrew.com/products/trans_line/radiax/default.aspx>
3. <http://members.aol.com/homingin/equipment.html>
4. <http://www.arrl.org/news/stories/2005/08/03/7/?nc=1>
5. <http://members.aol.com/homingin/intlfox.html>

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Painting Antennas

Painting antennas was first recommended to me by WB6NMT. Louie ran Lunar Electronics and sold a fine line of antennas. He also lived near the Pacific coast, and thus his antennas were subjected to a lot of salt spray. If paint helps antennas last a few more years in salt spray on the coast, then it will help them last decades longer here in inland Texas. My 432-MHz and 222-MHz Yagis were painted in 1979 and they are still up in the air (with a few touch-ups over the years).

Painting antennas has several advantages (photo A). First, the paint tends to "glue" the hardware together. Not as many screws and nuts seem to work their way loose with some paint in the threads. Next, the paint protects plastic parts from ultraviolet light exposure and air pollution. Therefore, the antenna holds together longer and fewer bits fall off if it is painted.

I had several reservations about how the paint might detune the antenna. I built a 3.45-GHz loop Yagi and measured its gain. Then I gave it several coats of spray Zynolite, epoxy paint. I let the paint set and then measured the gain again. There was no measurable difference. If I can't measure any loss at 3.45 GHz, I'm not going to worry about paint losses with my 2-meter beam.

Next I used a light-gray -paint. It used to be called "Battleship Gray," but Machinery Gray is a common color among the better spray paints, and when the sky is just a little overcast, the antennas virtually disappear. Louie painted his antenna white, but I like to keep mine somewhat lower profile.

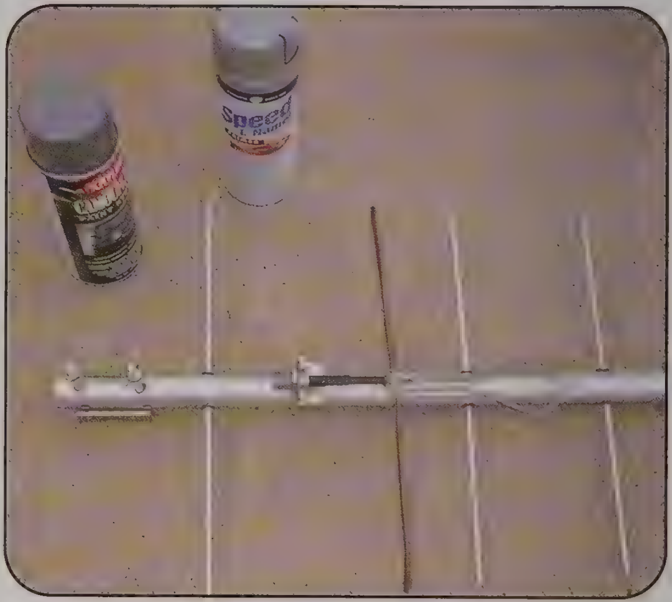


Photo A. Painting an antenna protects the plastic parts from ultraviolet light and pollution and also tends to "glue" the hardware together.

Cheap RAM

RAM, or radar-absorbing material in this case, has many UHF and microwave applications. Coating an aircraft or pickup truck with it is just one possible use.

I have to give credit here to Bob, W5EMC, for this tip. Military RAM is selected blends of ferrite dust in a silicon rubber matrix. Often a wire mesh is added for strength and to improve the RAM's characteristics at a spot frequency. Well, those magnetic signs often seen on a pickup saying, for example, ACME Lawn Care, or the little signs that hold a business card to the refrigerator, are made of a very similar material (photo B). In EMI/EMC work, a strip of this magnetic silicon rubber is placed over particularly noisy chips to help the board pass FCC emissions standards. For ham use we can think of this stuff as sheet ferrite beads.

In a future column we will be covering some projects using magnetic-particle-loaded material. It makes great microwave dummy loads, can be used with dish feeds to reduce sidelobes, and can be placed in the lids of microwave project boxes to kill resonances. I personally find a few drops of Goo-Gone® work great for separating the magnet itself from the advertisement. Keep an eye out for those sheet magnets. Start collecting old magnetic signs!

Reader Question

Paul B. asks, "How close to the tower can I side-mount a Ringo Ranger without messing up the pattern or the SWR?"

This question covers just about any ground-plane or Ringo-style antenna. You just can't always put your antenna at the top of the tower mast.

There are two issues here. The first is how close can the antenna be to the tower before the tower changes the SWR of the antenna (figure 1).

Photo B. Magnet signs seen on vehicles or holding a business card to a refrigerator are made of a material very similar RAM (radar absorbing material). For ham use the material can be thought of as sheet ferrite beads.

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Distance	146 MHz SWR	New Frequency and SWR at that Frequency
12 inches	1.5	144 MHz, 1.35 SWR
18 inches	1.5	144 MHz, 1.3 SWR
24 inches	1.17	145 MHz, 1.12 SWR

Table I. How close to the tower can you place an antenna before the tower changes the SWR of the antenna? Here are my results at different distances, including the new resonate frequency.

I started with a 2-meter vertical and measured the SWR at different distances. All by itself the antenna had an SWR of 1.25 at 146 MHz. Moving the 2-meter vertical near the tower lowered the vertical's resonant frequency due to the loading effects of the tower. Table I shows my results at different distances, including the new resonant frequency. At 24 inches from the tower the antenna had a better SWR at 146 MHz than it did when it was on a pole all by itself. However, I'm pretty sure that can be attributed to a less than optimum SWR match when I started. It does show, though, that you can place a 2-meter vertical within 12 inches of a mast or tower and all you need to do is shorten it less than an inch or so to get the antenna back on the starting frequency.

The pattern was a very different story. Even when I mounted the antenna 10 feet from the tower, the tower still distorted the vertical's pattern. This may not be all that bad. The vertical and the tower tended to form a two-element Yagi. Also, from a mounting offset distance of 12 inches to an offset of 48 inches the pattern didn't change very much. The signal behind the tower was a consistent –4 dB. In the direction where the reflected signal adds, the gain was running between +4 and +5 dB.

For a better pattern I broke down and built an NEC model using the EZNEC 4.0 modeling software. As you can see in figure 2, the nulls are not on the opposite sides of the tower, but rather at ±120 degrees. That 120-degree angle varied a bit with distance but was pretty consistent for all distances at which the antenna was mounted from the tower.

Therefore, the tower offset can be used to shade a repeater, etc., about 4 dB. That's not all that much, which can be good news or bad news. You can get better shading/blockage at ±120 degrees, but the position may need a little tweaking for your tower. Off the other side you're picking up almost an S-unit more signal. In short, mount the vertical on the side of the tower where you need a bit more signal.

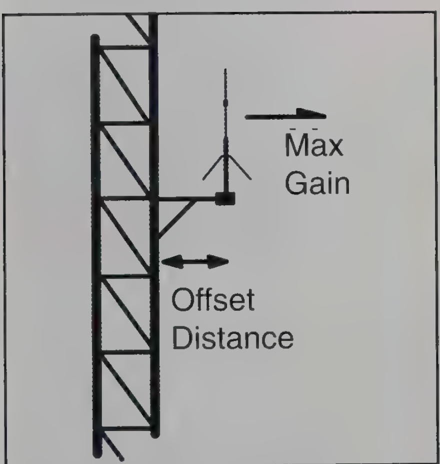

Figure 1. Tower offset distance.

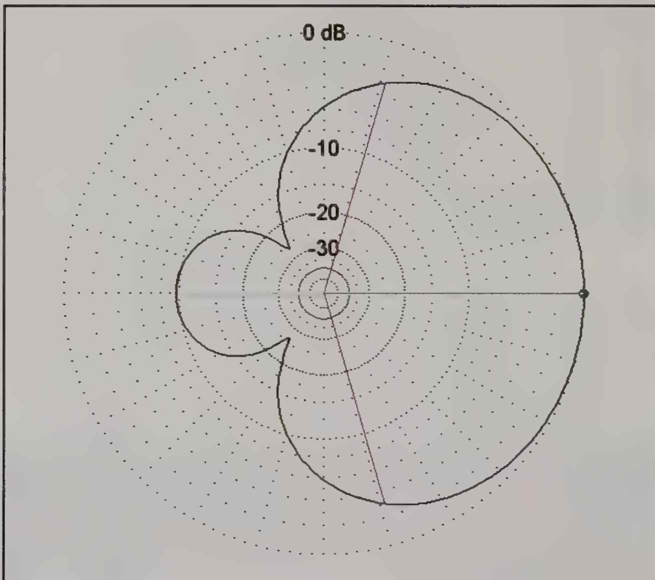

Figure 2. Tower and pattern with a 2-foot offset.

For a nearly omni pattern, the antenna needs to be more than 6 feet from the tower. For a 440-MHz vertical, just divide all of my distances by 3. About a foot of offset is all you need.

Neat Ideas

I have always gotten some of my best ideas for articles from you, our readers. How about going to the next level? Do you have any neat ideas you would like to share with other readers? A trick for grounding a mobile vertical? A simple way of attaching a coax connector? Using something unusual to build your antenna? Let me know, and we'll make a short topic out of it for a future column.

Photo C. Building Yagi antennas on hockey sticks. (Tnx to Denis in Quebec)

From Denis in Quebec we have a suggestion for building Cheap Yagis out of broken hockey sticks (photo C). I'll have to take his word on it, as we don't see very many used hockey sticks in Texas, but that hard wood should make a pretty good boom.

Next Time

Keep a look out for those magnetic sheets, and we'll cover some ways you can use them in a future issue of *CQ VHF*. Also, I plan to cover several cases where a $^1/_4$-wave antenna is a terrible choice. Yes, there are times when a $^1/_4$-wave antenna isn't doing what you think it is.

And remember . . . Anything in the air works better than the perfect antenna still on the drawing board!

73, Kent, WA5VJB

By Tomas Hood,* NW7US/AAA0WA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Is the End of Cycle 23 Near?

Does solar Cycle 23 have enough life left to spark some excitement for those of us hunting for exotic VHF propagation? Also, what is the outlook for Cycle 24?

The current cycle has not been too exciting for VHF enthusiasts, with Cycle 23 peaking at a smoothed sunspot number of 120.8. That's a bit dismal compared to previous cycles. Cycle 21 peaked at 164, and Cycle 22 peaked at 158. Compare these last three 11-year solar activity cycles to Cycle 19 from the late 1950s, which had a smoothed peak of 201.3. That's a cycle remembered fondly among VHF veterans, with frequent worldwide *F*-layer openings on 6 meters and plenty of aurora-mode propagation.

The official prediction for the ending of the current solar cycle is around the end of 2006. This prediction has not been changed for several years and is thought to still be valid. However, a panel of scientists is planning to meet in early 2006 and hopes to provide an update in April 2006. I don't expect the outlook to change too much, and I continue to postulate the end of Cycle 23 to occur in the fall of 2006.

Despite the impending death of Cycle 23 in about a year's time, there have been recent moments of rather energetic bursts of solar activity. An example occurred during September, when a huge sunspot rounded the sun's eastern limb. As soon as it appeared it exploded, producing one of the brightest x-ray solar flares so far recorded (see Table 1). As it traversed the visible solar disc, the complex and ever-growing spot exploded at least nine more times. Each X-class flare caused a radiation storm and provided conditions for modest aurora-mode propagation. On September 10th and 11th, ruby-red auroras were seen as far south as Arizona.

It is typical during the decline of recent solar cycles to see moments of strong activity, although they are less frequent than in the years centered on a cycle's maximum. What makes 2005 unique, though, is the strength of these occasional solar flare-ups. The year started immediately on New Year's Day with the first of many X-class flares! Since then we've experienced four severe geomagnetic storms and 14 more X-flares.

Ranking	Day/Mo./Yr.	X-Ray Class
1	04/11/03	X28
2	02/04/01	X20.0
2	16/08/89	X20.0
3	28/10/03	X17.2
*4	*07/09/05	X17
5	06/03/89	X15.0
5	11/07/78	X15.0
6	15/04/01	X14.4
7	24/04/84	X13.0
7	19/10/89	X13.0
8	15/12/82	X12.9
9	06/06/82	X12.0
9	01/06/91	X12.0
9	04/06/91	X12.0
9	06/06/91	X12.0
9	11/06/91	X12.0
9	15/06/91	X12.0
10	17/12/82	X10.1
10	20/05/84	X10.1
11	29/10/03	X10
11	25/01/91	X10.0
11	09/06/91	X10.0
12	09/07/82	X9.8
12	29/09/89	X9.8
13	22/03/91	X 9.4
13	06/11/97	X9.4
14	24/05/90	X9.3
15	06/11/80	X9.0
15	02/11/92	X9.0

Table 1. Top X-flares so far recorded by scientists. The X17 flare of September 7, 2005 is marked by an asterisk (*). This list is based in part on "Large Solar Flares Since 1976," compiled by IPS Radio & Space Services.

"That's a lot of activity," says solar physicist David Hathaway of the National Space Science and Technology Center in Huntsville, Alabama. "In the year 2000," he recalls, "there were three severe geomagnetic storms and 17 X-flares." 2005 registers about the same in both categories!

September's activity was caused by sunspot 808. All by itself, this sunspot has made September 2005 the most active month on the sun since March 1991. All of this activity came out of a sunspot that had already made it around the sun once before as active region 798. When it returned a second time, it rotated into view with a bang. On September 7, 2005 this sunspot unleashed the fourth largest flare of Cycle 23 and was the fifth largest ever recorded. The flare measured in at X17! From that point onward, it continued to stir up space weather and influence radio propagation with at least nine more X-class flares. During some of these solar flares, coronal mass ejections (CMEs) were hurled toward the Earth, triggering geomagnetic storms and aurora. As I write this, this same sunspot group is just making its way around again for a third time and it shows continued, although much weaker, life (see images A, B, C, D).

Hathaway cautions against predicting the exact end of the current cycle. Before 2005, the last solar minimum was due in 1996, and at the time the sun seemed to be behaving perfectly: From late-1992 until mid-1996, sunspots began to disappear and there were precisely zero X-flares during those long years. It was a time of quiet. Then in 1996 when sunspot counts finally reached their lowest value, bang! An X-flare erupted.

"The sun can be very unpredictable," says Hathaway. When asked when we should expect the end of this cycle, he points out, "We need to observe more solar cycles to answer that question. And because each cycle lasts 11 years, observing takes time." (See image E.)

The prediction for the next cycle indicates that it will be a modest cycle, with no more than a maximum smoothed sunspot peak of 150. Regardless, I bet we'll have moments that will surprise us with explosive activity much like we've seen during this cycle. Its peak should be around 2009 through 2012, with a relatively fast rise from the cycle's start in 2007. A rapid rise has been typical during a number of recent solar cycles. Such a rise and subsequent peak period is great news for the VHFer, since it brings the

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Image A. At 1:40 PM EDT on September 7, 2005 forecasters at the NOAA Space Environment Center in Boulder, Colorado observed one of the largest solar flares on record. (Source: NOAA/SEC)

Image B. A close-up of the September 9, 2005 flare with the Transition Region and Coronal Explorer (TRACE) spacecraft. (Source NASA/LMSAL)

higher frequencies alive via an energized ionosphere and also provides the environment in which aurora-mode propagation is sustained.

Coronal Holes; The Origin of Solar Wind?

Outside of these moments of solar eruptions and geomagnetic storms from related CMEs, another major player during solar cycle minimums is the continual occurrence of coronal holes and the resulting solar wind storms. When the Earth is under the influence of high-speed solar winds, we often experience periods of geomagnetic disturbances that can develop into significant storms. That in turn triggers the aurora VHFers look forward to.

A Chinese-German team of scientists has identified the magnetic structures in the solar corona where these fast solar winds originate. They analyzed images and Doppler maps from the Solar Ultraviolet Measurements of Emitted Radiation (SUMER) spectrometer and magnetograms delivered by the Michelson Doppler Imager (MDI) on the space-based Solar and Heliospheric Observatory (SOHO) of ESA and NASA and found that solar winds were flowing from funnel-shaped magnetic fields that are anchored in the lanes of the magnetic network near the surface of the sun.

"The fine magnetic structure of the source region of solar wind has remained elusive," said first author Professor Chuanyi Tu, from the Department of Geophysics of the Peking University in Beijing, China. "For many years, solar and space physicists have observed fast solar wind streams coming from coronal regions with open magnetic-field lines and low light intensity, the so-called coronal holes. However, only by combining complex observations from SOHO in a novel way have we been able to infer the properties of the sources inside coronal holes. The fast solar wind seems to originate in coronal funnels with a speed of about 10 km/s at a height of 20,000 kilometers above the photosphere."

"The fast solar wind starts to flow out from the top of funnels in coronal holes with a flow speed of about 10 km/s," states Professor Tu. "This outflow is seen as large patches in Doppler blue shift (hatched areas in figure 1) of a spectral line emitted by Ne^{+7} ions at a temperature of 600,000° Kelvin, which can be used as a good tracer for the hot plasma flow. Through a comparison with the magnetic field, as extrapolated from the photosphere by means of the MDI magnetic data, we found that the blue-shift pattern of this line correlates best with the open field structures at 20,000 km."

Solving the nature and origin of the solar wind is one of the main goals for which SOHO was designed. It has long been known to the astronomical community that the fast solar wind comes from coronal holes. What is new here is the discovery that these flows start in coronal funnels, which have their source located at the edges of the magnetic network. Just below the surface of the sun there are large convection cells. Each cell has magnetic fields associated with it, and these are concentrated in the network lanes by magneto-convection, where the funnel necks are anchored. The plasma, while still being confined in small loops, is brought by convection to the funnels and then released there, like a bucket of water is emptied into an open-water channel.

"Previously it was believed that the fast solar wind originates on any given open field line in the ionization layer of the hydrogen atom slightly above the photosphere," says the second author, Professor Marsch. "However, the low Doppler shift of an emission line from carbon ions shows that bulk outflow has not yet occurred at a height of 5,000 km. The solar-wind plasma is now considered to be supplied by plasma stemming from the many small magnetic loops, with only a few thousand kilometers in height, crowding the funnel. Through magnetic reconnection, plasma is fed from all sides to the funnel, where it may be accelerated and finally form the solar wind."

Another group of scientists was surprised to discover that the structure of the sun's cooler, dense lower atmosphere, the chromosphere, could be used to estimate the speed of the solar wind. This was

Image C. A view of the aurora australis (southern lights) as taken by the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft on September 11th in ultra-violet light. (Source: NASA)

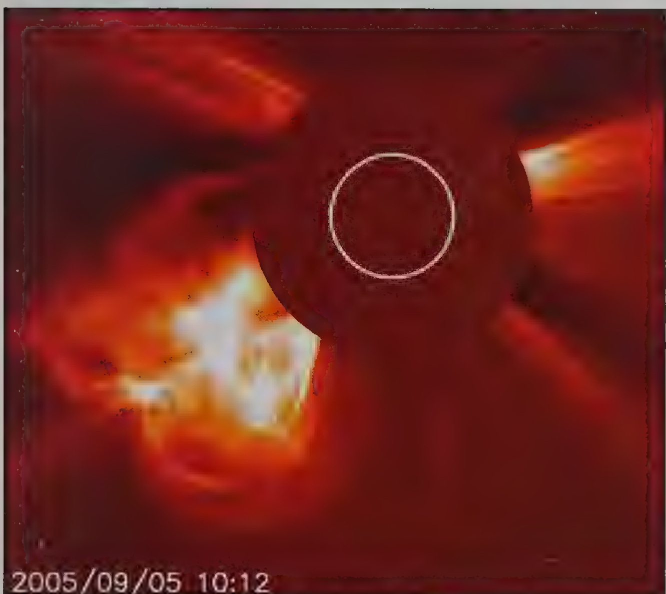


Image D. On September 5, 2005 the C2 coronagraph observed a bulbous coronal mass ejection heading out from behind the left side of the sun. This was about where old sunspot region 798 was expected when returning for a second rotation. The first time around it produced several substantial solar storms. It was probably the source of several large solar storms that we could infer occurred on the far side of the sun. The region was tracked using the sensing techniques of helioseismology. Also, just as scientists suspected, the same region, while still just at the sun's left edge on the second rotation, erupted two days later with an X17 flare (almost off the scale) and an associated CME. At press time it has made it a third time around the sun, but is much weaker this time around. (Source: SOHO)

unexpected, because the solar wind originates in the corona, and the chromosphere is much deeper (it lies just above the sun's visible surface). "It's like discovering that the source of the river Nile is another 500 miles inland," said Dr. Scott McIntosh of the Southwest Research Institute, Boulder, Colorado, lead author of a paper on this research published May 10, 2005 in the *Astrophysical Journal* (see figure 2).

The new work promises to increase the accuracy of space radiation forecasts. When the sun unleashes a CME (a billion-ton blast of plasma) into space at millions of miles per hour, it is likely to trigger geomagnetic storms. The VHF enthusiast benefits from a forecast that accurately identifies a pending storm, because that would signal the possible auroral propagation soon to commence.

"Just as knowing more details about the atmosphere helps to predict the intensity of a hurricane, knowing the speed of the solar wind helps to determine the intensity of space radiation storms from CMEs," said co-author Dr. Robert Leamon of L-3 Government Services at NASA's Goddard Space Flight Center, Greenbelt, Maryland.

The solar wind is gusty, much like winds on Earth, and ranges in speed from about 750,000 miles per hour (approximately 350 kilometers per second) to 1.5 million miles per hour (700 kilometers per second). You can view the current solar wind speed as measured by sending your internet web browser to <http://www.sec.noaa.gov/SWN/>.

Since the solar wind is made up of electrically charged particles, it responds to magnetic fields that permeate the solar atmosphere. Solar-wind particles flow along the invisible lines of magnetic force. When the magnetic field lines stretch straight out into space, as they do in coronal-hole regions, the solar wind will move along these magnetic lines at a very high rate of speed. However, when the magnetic field lines bend sharply back to the solar surface, like the pattern you see with iron filings around a bar magnet, the solar wind emerges relatively slowly. For over 30 years this model has allowed space weather scientists to create a crude estimate for the speed of the solar wind.

In the new work, the team has tied the speed of the solar wind as it blows past Earth to variations deeper in the solar atmosphere than had previously been detected, or even expected. By measuring the time taken for a sound wave to travel between two heights in the chromosphere, they were able to determine that the chromosphere is effectively "stretched thin" below coronal holes with their open magnetic fields, but compressed below magnetically closed regions.

The team used the observation to derive a continuous range of solar wind speeds from the structure of the chromosphere. The wider the chromospheric layer, the more it is being allowed to expand by open magnetic fields and the faster the solar wind will blow. This new method is more precise than the old "fast or slow" estimate (see figure 3).

NASA's Transition Region and Coronal Explorer (TRACE) spacecraft was used to measure the speed of sound waves in the chromosphere, and NASA's Advanced Composition Explorer (ACE) spacecraft was used to take measurements of the solar wind speed as it blew by the Earth. Comparing the data from the two spacecraft gave the connection.

"Prior to this discovery, we could only determine solar wind speed from spacecraft that were roughly in line between the Earth and the sun, such as ACE, WIND, and the Solar and Heliospheric Observatory. This spacecraft fleet was placed along the Earth-sun line because we need to know about the space weather coming our way. However, compared to the size

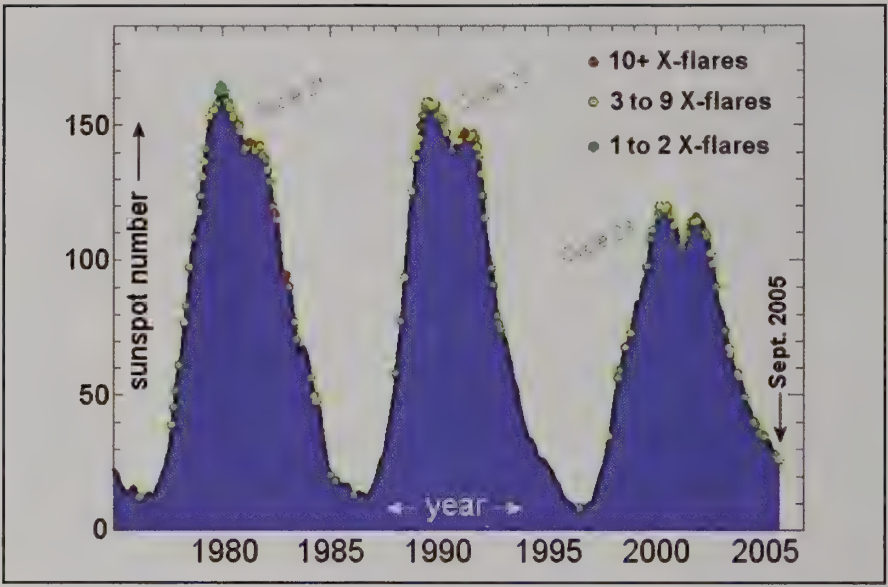


Image E. Sunspot counts and X-flares during the last three solar cycles. Note how solar activity continues even during solar minimum. (Source: David Hathaway, NASA/NSSTC)

of our solar system, this is a very narrow range; it's like looking through a soda straw. With this discovery, we can use TRACE to build up images that can predict the solar wind speed throughout half the solar system," said Dr. Joe Gurman, a solar researcher at NASA Goddard.

This is a welcomed development, since the radio hobbyist can now better assess the probability of geomagnetic activity that would trigger conditions useful for VHF propagation. By knowing more accurately when a solar-wind shock wave will arrive, and how intense the plasma cloud will be, combined with the orientation of the magnetic components, the VHF radio amateur/scientist can be ready for action. With the VHF radio community ready for these opportunities, more participants will be on the scene to make these openings memorable.

When the interplanetary magnetic field lines are oriented opposite to the magnetosphere's orientation, the two fields connect and allow solar-wind particles to collide with oxygen and nitrogen molecules in the upper atmosphere of these ovals. This causes light photons to be emitted. When the molecules and atoms are struck by these solar-wind particles, the stripping of one or more of their electrons ionizes them to such an extent that the ionized area is capable of reflecting radio signals at very high frequencies. This ionization occurs at an altitude of about 70 miles, very near the *E*-layer of the ionosphere. The level of ionization depends on the energy and amount of solar-wind particles able to enter the atmosphere.

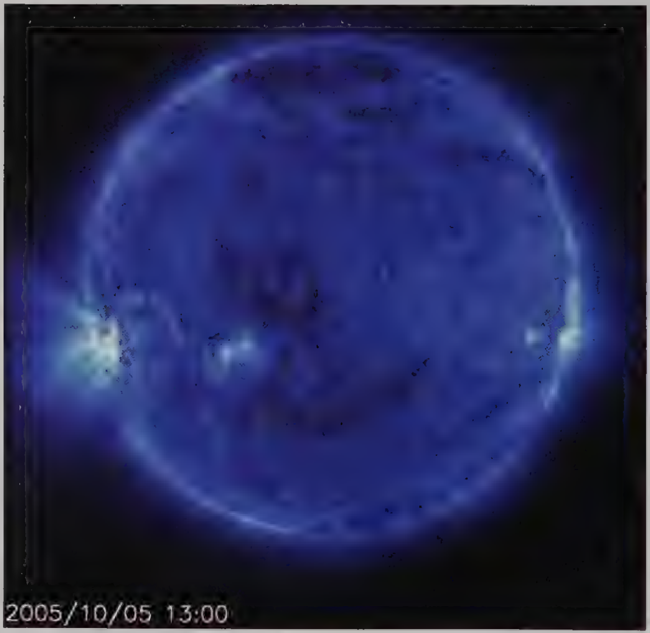


Image F. The third return of sunspot region 798/808 (on the left of the image), still active after three rotations! (Source: SOHO)

While correlations exist between visible and radio aurora, radio aurora could exist without visual aurora. Statistically, a diurnal variation of the frequency of radio-aurora QSOs has been identified and suggests two strong peaks, one near 6 PM and the second around midnight, local time.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K*-index is a good indicator of the expansion of the auroral oval, and the possible intensity of the aurora. When the *K*-index is higher than 5, most readers in the northern states and in Canada can expect favorable aurora conditions. If the *K*-index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida.

For the daily conditions, you are welcome to check my propagation resource at <http://prop.hfradio.org>, where I have the current planetary *K*-index, links to various aurora resources, and more. You can get the same information on a cell phone that is WAP-enabled by using the cell phone's web browser to view <http://wap.hfradio.org/>.

Autumn Outlook

Autumn (November through January) is a relatively quiet season, with very little if any transequatorial propagation (TEP). TEP, which tends to occur most often during spring and fall, requires high solar activity that energizes the ionosphere enough to cause the *F*-layer over the equatorial region to support VHF propagation. The normal TEP signal path is between locations on each side of the equator. However, without the level of solar activity needed to keep the *F*-layer

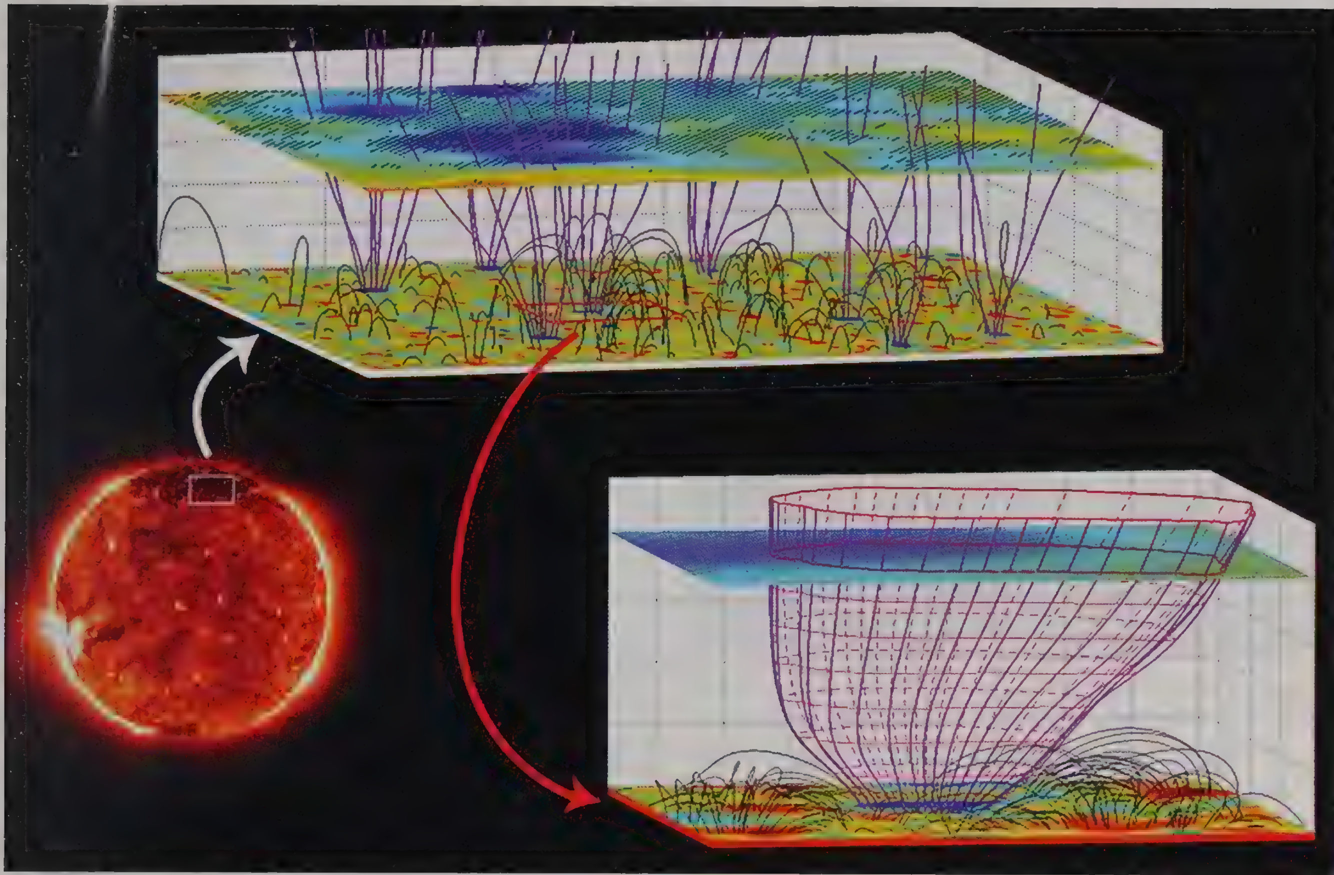


Figure 1. This picture was constructed from measurements which were made on September 21, 1996 on SOHO (see the April 22 issue of SCIENCE *magazine). The figure illustrates location and geometry of three-dimensional magnetic-field structures in the solar atmosphere. The magenta-colored curves illustrate open field lines, and the dark-gray solid arches show closed ones. In the lower plane, the magnetic field vertical component obtained at the photosphere by MDI is shown. In the upper plane, inserted at 20,600 km, the Ne VIII Doppler shift is compared with the model field. The shaded area indicates where the outflow speed of highly charged neon ions is larger than 7 km/s. Note the funnel constriction by pushing and crowding of neighboring loops. The scale of the figure is significantly stretched in the vertical direction. The smaller figure in the lower right corner shows a single magnetic funnel, with the same scale in both vertical and horizontal directions. (Source: MPI for Solar System Research)*

energized enough for VHF propagation, these paths don't materialize. The fall season of TEP usually tapers out by mid-November. This year, though, TEP will be rare, if it occurs at all.

Tropospheric-ducting propagation during this season is fairly non-existent, as the weather systems that spawn the inversions needed to create the duct are rare. On the other hand, using tropospheric-scatter-mode propagation is possible, but one needs to have very high-powered, high-gain antenna systems. Having dual receivers in a voting configuration would also help. The idea is to use brute force to scatter RF off water droplets and other airborne particles, and capture some of that signal at the far end with dual-diversity, high-gain receivers —not everyone's cup of tea.

In addition, since we're well past the second yearly peak equinoctial activity, aurora will occur less frequently, even during those less-frequent occurrences of solar wind storms. Don't rule out aurora altogether, though. This cycle has surprised us enough times that it might well be possible to see another major flare unleashing a huge plasma cloud on a high-speed solar-wind stream directly at the Earth, triggering massive aurora. If and when that happens, fire up your VHF sideband equipment and work the aurora!

The Autumn Meteor Shower Season

There are a number of opportunities during this period to try your skill and use your equipment in meteor-scatter propagation. One of the largest yearly meteor showers occurs during November.

The *Leonids* meteor shower is typically the big event for November. This year it is expected to peak on November 17 at 1317 UT. There is a possible second outburst from a side trail from the comet, the 55P/Tempel-Tuttle, due at 0140 UT on November 21, most suited for Europeans. The full *Leonid* period is from about November 14 and continues through November 21.

Unfortunately, most are predicting that this year's shower will be dismal. An expected rate of only 16 to 20 bursts per hour will make the prospect for exciting meteor-shower radio propagation bleak.

The reason behind the low hourly rate lies in the size of the debris clouds left by the passing comet. These dust clouds are stretched out into long and narrow trails. The younger remains of recent passages are only ten or so Earth-diameters wide. The chances of Earth hitting something so narrow and filamentary are slim. This has proven true for most years in No-

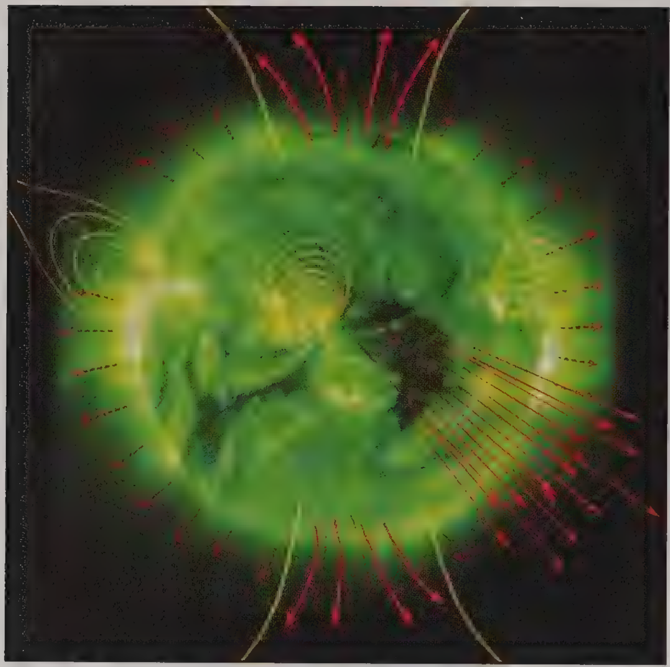


Figure 2. The sun's atmosphere is threaded with magnetic fields (yellow lines). Areas with closed magnetic fields give rise to slow, dense solar wind (short, dashed red arrows), while areas with open magnetic fields—so-called "coronal holes"—yield fast, less-dense solar wind streams (longer, solid red arrows). In addition to the permanent coronal holes at the sun's poles, coronal holes can sometimes occur closer to the sun's equator, as shown here just right of center. (Source: September 18, 2003 image from the SOHO Extreme ultraviolet Imaging Telescope; ESA/NASA)

vember, when we miss them completely. During these misses, Earth slips between the clouds, where there is only a sprinkling of meteoroids. At such times *Leonid* rates remain low—only 10 or 15 meteors per hour.

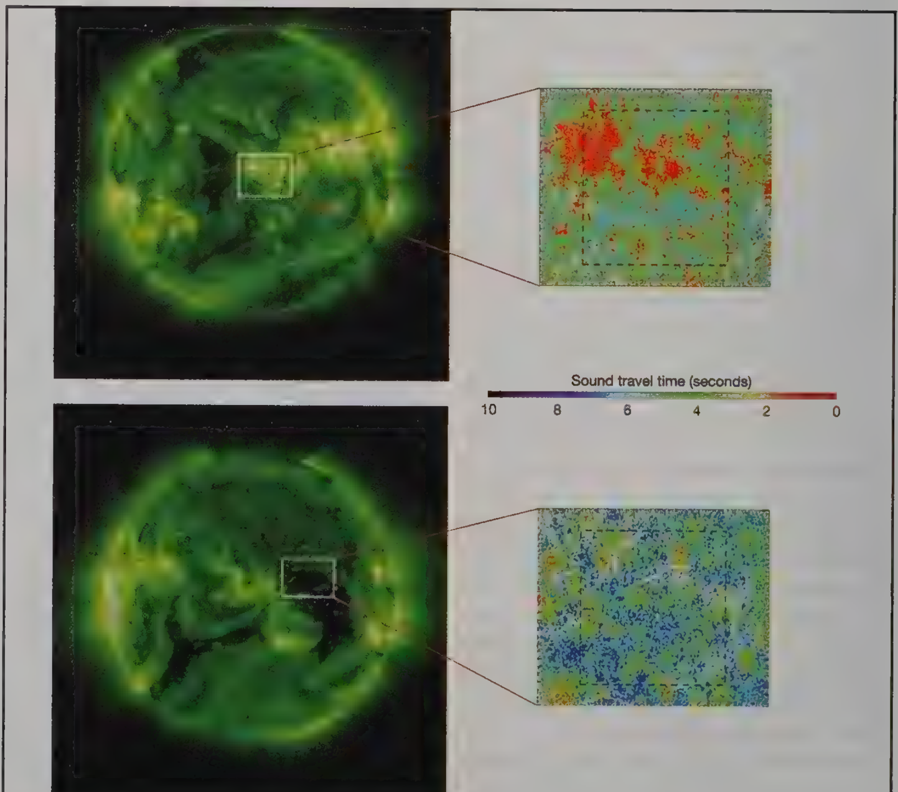
The most recent excitement during the November *Leonids* shower was between 1998 and 2002. In 1998 the comet returned to its perihelion (this term refers to the point where the comet is closest to the sun, during its orbit around the sun). This increased the debris trail enough to provide a nice increase in the hourly meteor rate. Since then, however, we've seen a steady decrease. However, it is possible that we could be surprised, if the Earth hits the dust cloud directly.

Remember that the *Leonid* radiant is best around local midnight in the Northern Hemisphere. Working VHF propagation off meteor tails (the highly ionized plasma trails left by the meteor) requires some reasonable power and gain, and good operating skill. With the latest high-speed burst-mode CW software, you possibly can work even the smaller meteors.

After the *Leonids,* the annual *Geminid* meteor shower from December 7 to December 17 will peak on December 13. This is one of the better showers, since as many as 120 visual meteors per hour (ZHR) may occur. *Geminids* is a great shower for those trying the meteor-scatter mode of propagation, since one doesn't have to wait until after midnight to catch this shower. The radiant rises early, but the best operating time will be after midnight local time. This shower also boasts a broad maximum, lasting nearly one whole day, so no matter where you live, you stand a decent chance of working some VHF/UHF signals off a meteor trail.

Finally, check out the *Quadrantids* from December 28, 2005 to January 7, 2006. This meteor shower is above average, with peaks with around 40 meteors per hour. The best day should be the morning of January 4, just after midnight, and working through predawn.

Figure 3. Sampling an area of the sun's upper atmosphere (shown approximately by the white outlines on the full sun images at left), McIntosh and Leamon used measurements made by NASA's TRACE spacecraft of a region with strong, closed magnetic fields on July 7, 2003 (top) and another region with weaker, open magnetic field on September 18, 2003 (bottom). The areas in red in the top "time difference" image show a shallow, dense chromosphere beneath an area with slow, dense solar-wind outflow; the areas in blue in the bottom image show a deep, less-dense chromosphere below a "coronal hole" with fast, tenuous solar-wind outflow. (Source: Images on left from the SOHO Extreme ultraviolet Imaging Telescope, ESA/NASA; images on the right from The Astrophysical Journal, *University of Chicago Press)*



Check out <http://www.imo.net/calendar/cal05.html> for a complete calendar of meteor showers in 2005.

Working Meteor Scatter

Meteors are particles (debris from a passing comet) ranging in size from a spec of dust to a small pebble, and some move slowly while others move fast. When you view a meteor, you typically see a streak that persists for a little while after the meteor vanishes. This "streak" is called the *train* and is basically a trail of glowing plasma left in the wake of the meteor. The *Leonids* are fast meteors and they leave a high number of long trains. They enter Earth's atmosphere traveling at speeds of over 158,000 miles per hour. Besides being fast, the *Leonids* usually contain a large number of very bright meteors. The trains of these bright meteors can last from several seconds to several minutes.

Meteor-scatter propagation is a mode in which radio signals are refracted off these trains of ionized plasma. The ionized trail is produced by vaporization of the meteor. Meteors no larger than a pea can produce ionized trails up to 12 miles in length in the *E*-layer of the ionosphere. Because of the height of these plasma trains, the range of a meteor-scatter contact is between 500 and 1300 miles. The frequencies that are best refracted are between 30 and 100 MHz. However, with the development of new software and techniques, frequencies up to 440 MHz have been used to make successful radio contacts off these meteor trains. On the lower frequencies, such as on 6 meters, contacts may last from mere seconds to well over a minute. The lower the frequency, the longer the specific "opening" made by a single meteor train. A meteor train that supports 60-second refraction on 6 meters might only support 1-second refraction for a 2-meter signal. Special high-speed methods are used on these higher frequencies to take advantage of the limited available time.

A great introduction by Shelby Ennis, W8WN, on working high-speed meteor-scatter mode is found at <http://www.amt.org/Meteor_Scatter/shelbys_welcome.htm>. Also, OZ1RH wrote, "Working DX on a Dead 50 MHz Band Using Meteor Scatter," a great working guide (http://www.uksmg.org/deadband. htm). W4VHF has also created a good starting guide at <http://www.amt.org/Meteor_Scatter/letstalk-w4vhf.htm>. Links to various groups, resources, and software are found at <http://www.amt.org/Meteor_Scatter/default.htm>.

The Solar Cycle Pulse

The observed sunspot numbers from July through September are 39.9, 36.4, and 22.1. The smoothed sunspot counts for January through March 2005 are 34.7, 34.0, and 33.6, continuing on the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from July through September 2005 are 96.6, 90.7, and 90.8. The smoothed 10.7-cm radio flux numbers for January through March 2005 are 100.3, 98.5, and 97.2.

The smoothed monthly sunspot numbers forecast for November 2005 through January 2006 are 19.2, 16.4, and 13.7. The current cycle does seem to have a more gradual decline slope than originally predicted, so adjustments are tending to be higher with each iteration. The smoothed monthly 10.7-cm values are predicted to be 80.2, 78.0, and 76.0 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A*-index (*Ap*) numbers from January through March 2005 are 14.7, 14.6, and 15.3. The monthly readings from July through September are 16, 16, and 21.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter?). I'll create summaries and share them with the readership. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information is found at my propagation center at <http://prop.hfradio.org/> and via cell phone at <http://wap.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73, Tomas, NW7US

The busy Red Cross Operations center "Intake" at Camp Gruber.

Chuck Myers, KW5I, at Red Cross operations "Intake" struggles to hear his radio over all the background noise in the busy center. Shortly thereafter we purchased and handed out ear buds to each operator.

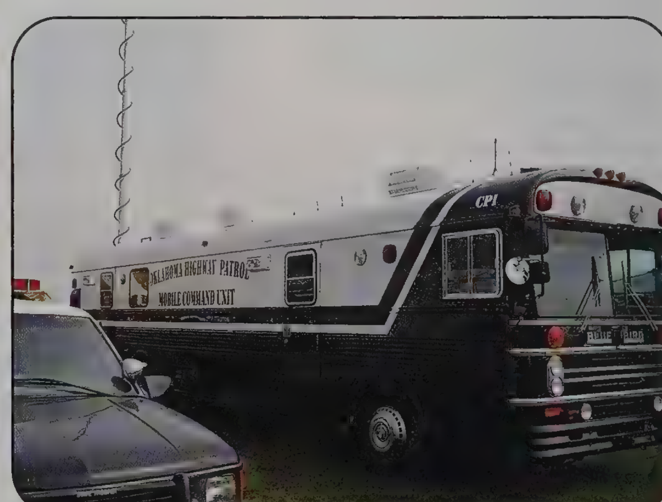
service projects. I made a call to ARRL Section Manager John Thomason, WB5SYT, and requested a formal declaration from ARES for additional operators. E-mail was sent out from ARRL HQ to amateurs in Oklahoma requesting their help. I went to work assessing our capabilities and mission requirements.

We needed to have operators at the main evacuee processing center for the Red Cross, the medical center, the front gate, the camp's warehouse (where all the logistic supplies were being sent), a triage center, and a mental-health facility. When the Oklahoma Highway Patrol mobile command post arrived, we also posted an operator on board the 60-foot-long converted bus. We also maintained communications with the National Guard operations via the loan of one of their commercial radios. In addition, we had two operators in Incident Command, one as net control, and one to answer phones or log. We were able to communicate throughout the entire camp via VHF on simplex. As the operations went on, we added a couple of runners/floats to cover during meal breaks and shift changes. By the end of our response operations, we were staffing eleven operators during the day and six at night.

Shortly before 10 AM Sunday, Steve Palladino, an Emergency Management Officer for ODEM, arrived in the incident command. Oklahoma has spent millions of dollars on equipment that allows interoperability of communications. When I asked Palladino if the interoperability communications trailer (known as ECHO 1) was coming, Steve told me that it was "out of pocket," which is what happened to many of the "first in" resources from some agencies in our area. "Out of pocket" means that they were deployed to the major disaster in the Gulf region. Palladino and I spent a few minutes covering where we had or would have operators. He said, "You guys are great. Thanks for jumping in to help." I asked him how long he would expect to need amateur radio. Palladino then replied, "for the duration."

Amateur radio was the communications backbone at Camp Gruber. We han-

Fred Williams, KD5NBR "NIC 5," at the microphone in IC (Incident Command).



The Oklahoma Highway Patrol Mobile Command Center (amateur radio optional).

dled traffic requesting supplies for each of the various locations, provided names to the front gate as to who had access to the camp, and acted as the 911 system on the camp. You name it; we communicated it. At most disasters amateur radio can stand down in two to three days as regular lines of communication come back on line. This was going to be a long-term response. We were going to need more help and a command structure to ensure a clear chain of command and a stronger organization when interfacing with the served agencies. We put into place a command system that mirrored what many police and fire departments use with a commander and assistant commander. We also had shift commanders (NIC—Net Controller in Command) at both Camp Gruber and Red Cross HQ in Tulsa. The NIC's job was to run the shift and to be the point of contact with served agencies. This system worked well for our emergency communications operation.

One of the challenges we encountered during this operation was some of the hams who wanted to help either did not own a handie-talkie or owned one of the small, compact, low-power units. This was a small roadblock in keeping communications going 100 percent of the time. With the help of Jim Pickett, K5LAD, who worked the phones, and with the help of ARRL headquarters, we secured the donation of ten new ICOM handie-talkies. These radios were welcomed and very useful tools. The other big challenge was something all volunteers face: the desire to help where we can—help load water, or make sandwiches or coffee, etc. We all want to help. That's not a bad thing, but it sometimes just gets in the way of communications. When an amateur radio operator is "helping," the operator is not watching and monitoring the radio. The NIC held a shift briefing each shift change and explaining to operators why "helping" was not their job. NIC also discussed turning auto-power OFF on radios, another problem.

To help reduce the noise factor, we purchased and issued ear buds to everyone. Thanks to the Tulsa Area Emergency Management Agency (TAEMA), which loaned us ten orange vests labeled COMMUNICATIONS, we were more visible. All of this structure was useful in making the response a success.

The mission of those at Tulsa Red Cross HQ also changed. Their job was to maintain contact with Camp Gruber 24/7 and they were responsible for recruiting operators for the needed positions. That was a big job. Zach Miller, K5BCT, and Mike Darrol, KD5RJZ, were the NICs at Red Cross HQ and worked very hard. They put together a phone pool to call hams. Area clubs e-mailed club rosters to the comm center at Red Cross to help with the recruiting effort.

It was Tuesday, September 6 before the telephones at Camp Gruber were stable and the internet access at the camp was working. Miller, K5BCT, and Darrol, KD5RJZ, also acquired a PC that was installed at the communications center at Camp Gruber. The PC was connected to the internet, and using Yahoo messenger, we were able to send traffic back to Tulsa more effectively via the Yahoo instant messenger. That was right out of the ECOMM course . . . use what works to get the message through.

From passing emergency traffic during day-time operations at the Tulsa Red Cross headquarters right after hurricane Katrina hit to the 24/7 (from Friday 9/2 to Sunday 9/11) operations supporting the mass shelter in Braggs, Oklahoma, more than 80 Oklahoma operators worked together. There were no club politics, no Oklahoma City versus Tulsa, no old hams versus young hams. We all worked together to get the message through.

As we were standing down Sunday afternoon, September 11, Steve Palladino of ODEM said of amateur radio, "...very useful. Interoperability between agencies at all the points of contact is a very important part of disaster communications." Palladino added, "Lots of folks had radios FRS, GMRS, or commercial radios. However, some did not know how to use them or how to communicate via a radio. Hams are great; you are trained and know how use your radios and how to communicate."

At the 6 PM briefing on September 11, 2005, when the ODEM announced that amateur radio was standing down, many thanks were passed on by all the served agencies: ODEM, Oklahoma Highway Patrol, American Red Cross, Oklahoma National Guard, and more. All were very impressed with the professionalism and can-do spirit exhibited by Oklahoma amateur radio operators assisting with this ECOMM response.

We amateur radio operators on site and at the Red Cross in Tulsa packed up our gear and went home, proud to have been able to do our part to help in emergency circumstances. When all else fails, amateur radio works. ■

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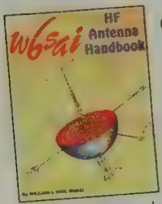

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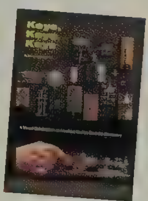

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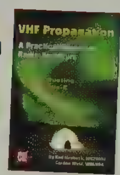

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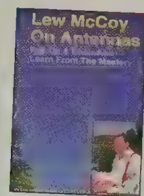

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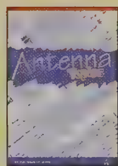

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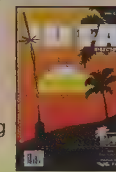

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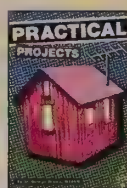

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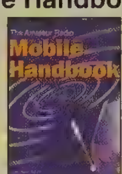

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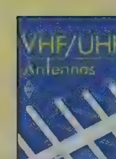

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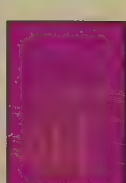

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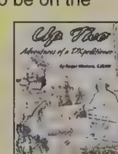

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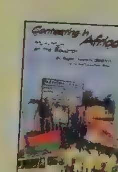

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Shouting in the Jungle

Nearly half a century of SETI science, and still not a single confirmed transmission from "Beyond." What kind of DXpedition is this?

When Frank Drake conducted the world's first SETI experiment in 1960, he was just days into the project when he heard a loud, periodic signal from Up There. "My God," he thought, "could it really be this easy?" The signal was, of course, RFI, a phenomenon with which every subsequent effort to detect evidence of extraterrestrial intelligence has been plagued. No, it *wasn't* that easy, then or now. The bands, it seems, are dead.

After a while, when the band seems dead, any sensible ham will want to stir the pot. So why aren't we calling CQ?

The whole question of transmitting from Earth is fraught with controversy. Every ham knows that if everyone is listening and no one is transmitting, no one is going to know when a band opening occurs. That's one of the reasons why we put propagation beacons on the air from exotic locations. Early on, SETIzens thought that advanced extraterrestrial civilizations would accommodate us immature Earthlings by providing just such beacons, to draw us into membership in the Galactic Club. Thus, the early SETI experiments, beginning with Drake's, concentrated on searching nearby sun-like stars for just such strong and steady beacons. If they are abundant, you'd think we would have heard one by now.

We haven't, though, and not necessarily because the bands are dead. Maxwell's laws quantify propagation, and they suggest that even a modest beacon, properly aimed, will easily be detectable by Earth's receive technology, across the interstellar gulf. Maybe, then, it's time to rethink our assumptions. Advanced civilizations, if indeed they exist, apparently *don't* announce their presence using radio waves. Do they perhaps know something we don't?

*Executive Director, The SETI League, Inc., <www.setileague.org>
e-mail: <n6tx@setileague.org>

Put out a CQ, or build a beacon of our own, many urge. If somebody doesn't break radio silence soon, the universe is going to remain a pretty lonely place. However, it's a dangerous universe out there, others argue. If you transmit, you're giving your position away to possible predators. No sane species shouts in the jungle.

Thus, the argument has raged for as long as humans have pursued SETI science. The only trouble is, no one knows what the risk of transmission really is, and we've never had tools to quantify it. Until now. . . .

It's widely recognized that not all transmissions are created equal. QRP is likely to pose less of a hazard to humanity than QRO, and a steady carrier is likely to be more detectable than a random pulse in the night. The level of risk associated with a given photon is related to its detectability, and detectability is a function of power, duration, direction, and information content. If we could assess all those, we could readily decide which transmissions are potentially hazardous and which are benign.

That is exactly what was proposed last spring in San Marino, a tiny republic perched on a mountaintop surrounded on all sides by Italy. San Marino, you see, maintained its independence for half a millennium, throughout countless wars of conquest, not by maintaining radio silence, but rather by having defensible borders in the form of steep cliffs. The ancient Roman catapults lacked the thrust to hurl rocks that high, so San Marino remained secure in its own 49 square kilometers of sovereign land.

But I digress. The Republic of San Marino hosts an annual SETI conference every March. This past March a friend of mine, an astronomer from Budapest, presented a paper there proposing a way to quantify at last the risk of transmitting from Earth. Iván Almár's proposal instantly became known as the San Marino Scale. (Yes, that's the same Iván Almár who concocted the Rio Scale for quantifying reception of SETI signals, as discussed in last quarter's column in *CQ VHF*.) Although no international body has yet adopted the San Marino Scale as a standard, it is a promising tool that helps us to contemplate the consequences of our actions.

Value	Potential Hazard
10	Extraordinary
9	Outstanding
8	Far-reaching
7	High
6	Noteworthy
5	Intermediate
4	Moderate
3	Minor
2	Low
1	Insignificant

The San Marino Scale is an ordinal scale between one and ten used to quantify the relative risk of a given electromagnetic transmission from Earth. Each numeric San Marino Scale value correlates to a subjective measure of risk, from Insignificant to Extraordinary.

Here's how it works: The San Marino Scale is an ordinal scale between one and ten used to assess the potential risk of employing electromagnetic communications technology to announce Earth's presence to our cosmic companions, or of replying to a successful SETI detection. In computing the San Marino index value, we must consider the power level of a given transmission not in absolute terms, but as a logarithmic ratio relative to the current background radiation from Earth in that particular frequency range. (We live on a radio-polluting planet. Only signals significantly stronger than our background noise are likely to stand out and be noticed.) We also consider where the antenna is pointing (straight down

doesn't represent much of a hazard), the signal's duration (for centuries key-down certainly has been more detectable than random bits), and information content (the more we say, the more *they* learn about us). Plug all these factors into an equation, and the San Marino number emerges. The higher the number, the more hazardous a given transmission should be considered.

I won't belabor the math here. The whole scale is explained in great detail on the website of the International Academy of Astronautics,[1] SETI Permanent Study Group, which I am privileged to co-chair. You can see it, and try it on for size, by browsing to <http://iaaseti.org>. On the left-hand main menu, click on Protocols, and then on San Marino Scale to find full disclosure. There's also a JavaScript calculator there to find out just how detectable (and, by some reasoning, just how hazardous) your EME station or OSCAR uplink might be.

No, I'm not proposing that any of us stop transmitting. However, before we reply to ET's CQ or broadcast one of our own, it would be nice to know the level of risk to which we are committing our defenseless planet. The San Marino Scale will tell us that. It will also provide the would-be regulators with a quantitative tool.

For years, the SETI community has been engaged in ongoing policy and protocol discussions dealing with the possibility or advisability of issuing either binding or voluntary restrictions or prohibitions against deliberate transmissions from Earth. The proponents of the San Marino Scale recognize that not all such transmissions imply the same level of risk or hazard. We hope that the international SETI community will consider using this tool for helping to define a threshold below which no prior consultation may be required in the event of a transmission from Earth, but above which discussions should take place, and a consensus be sought, prior to engaging in active SETI or replying to received signals.

Where do I stand? As a ham, I am committed to communicating. I'm loath to hide in my hilltop fortress, fending off invading Romans. Then again, though, I'm not the sole inhabitant of this planet. If my actions have the potential to affect others, it behooves me to analyze the consequences before I commit my whole planet to a course of communications and contact. The San Marino Scale will help me do that.

73, Paul, N6TX

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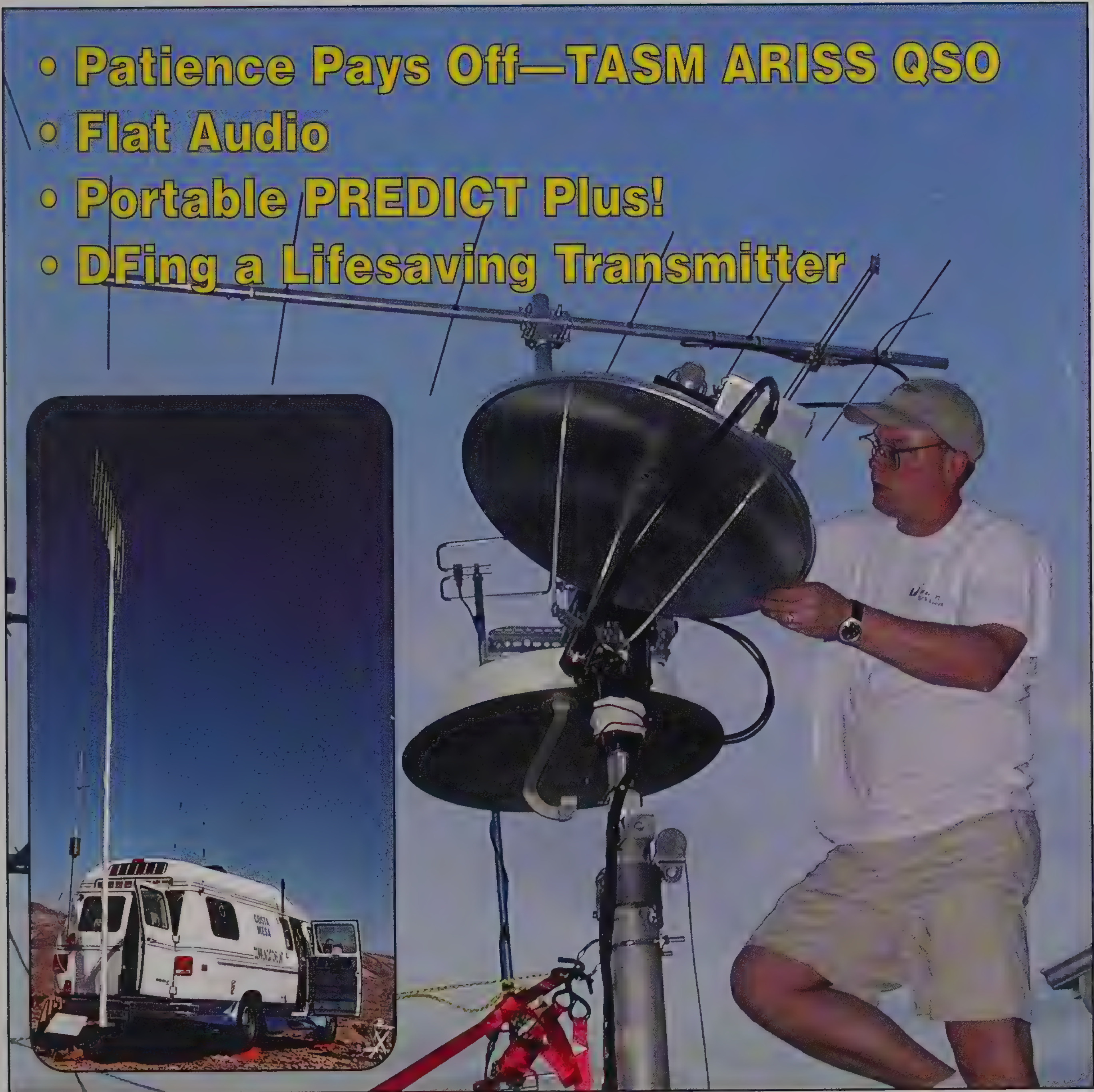

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Vol. 7 No. 4

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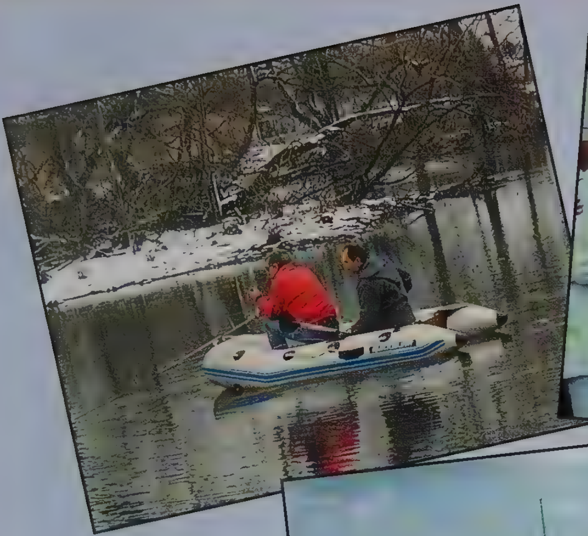

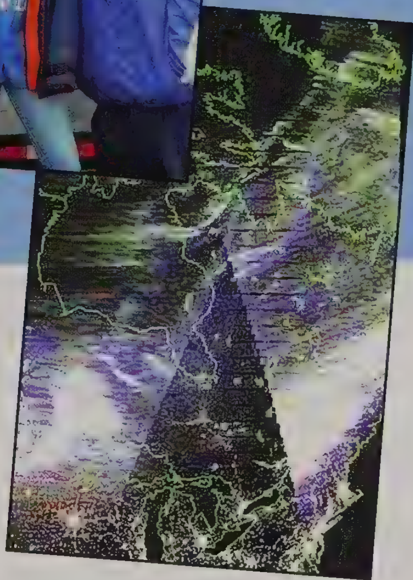

COLUMNS

DEPARTMENTS

On The Cover: When it rains, it propagates! For details see p. 6. Photo by Mike King, KMØT. Inset photo see p. 11.

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

A Not So Mild Embarrassment

It was in late December that *Time* magazine writer Lev Grossman wrote his piece "Blogs have their day," in which he initially compares bloggers to the "mildly embarrassing hobbies of ham radio and stamp collecting." Within the week the disastrous tsunami hit South Asia, killing more than 150,000 and injuring hundreds of thousands of others.

As with countless other natural and man-made disasters, ham radio operators immediately went to work to provide critical emergency communications. From a DXpedition that became the only source of health and welfare traffic between India and Andaman and Nicobar Islands, to hams throughout Thailand using 2 meters as their primary band of operations, came two examples of critical communications that were being handled by amateur radio operators. More information on how HSMM has been playing a role in the emergency communications can be found in the "HSMM" column (beginning on page 30) by John Champa, K8OCL.

As these examples indicate, hams continue to prove that we are made of the right stuff. However, as the Grossman piece indicates, we have a long way to go to improve our public image.

As the disaster continues to unfold, the needs of the area will continue to present themselves to the rest of the world for many months to come. If you have not already given to the needs, I urge you to generously respond to them by way of contributions to the charity of your choice.

Amateur Radio and Education

There have been more than 150 educational-related contacts with the International Space Station and the space shuttles. Even so, each time is unique and each time is special—particularly for the participants. Beginning on page 8 in this issue of *CQ VHF*, "Satellite" column editor Keith Pugh, W5IU, describes one of the recent QSOs with the ISS.

Getting back to Grossman's article, as an observer of this particular ARISS QSO, I did not detect one hint of embarrassment among any of the participants as the hobby of ham radio was being used to further the education of the school children. Rather, what I saw was pride in accomplishment for all concerned, as, according to Keith, this was one of the more successful ARISS contacts.

DFing a Lifesaving Transmitter

In another fun aspect of the hobby that has a potentially far-reaching public-service spinoff, in this issue Pete Ostapchuk, N9SFX, describes how he and another ham, Ritch Williams, KA9DVL, went DFing for a lost lifesaving transmitter. This type of transmitter is one that is used as a tracking device for people who might become lost and not be able to assist themselves in their predicament, such as Alzheimer's patients.

As Pete tells the story, when one of the devices that were being demonstrated went missing and conventional methods failed to locate it, amateur radio came to the rescue—and quickly found it. Commenting on the amateur radio involvement, Pete stated, "I keep hearing people talk about how cell phones and computers are taking the spotlight away from amateur radio. It's pretty obvious that when the call for help went out in this instance, it didn't go out to computer and cell-phone users." The whole story begins on page 26.

The Unusual Propagation of November 2004

This past November 7–10 we had both aurora and unseasonable sporadic-*E* propagation on our lower VHF+ bands thanks to a large flare eruption on the sun on November 7. In his "Propagation" column Tomas Hood, NW7US, goes into some detail, explaining what happened to bring about these propagation events. Also in this issue, Ken Neubeck, WB2AMU, reports on his experiences during those events (see page 42).

The Increased Variety of Use of the VHF+ Bands

The above-mentioned articles are just a sampling of what is in this issue. It is with this Winter 2005 issue that we conclude three years of the experiment of bringing back *CQ VHF* magazine. By all accounts, the experiment is working. You are accepting the new format and supporting it with your submission of articles and purchase of subscriptions, as well as telling others about it.

What has fascinated me the most over these past three years as editor of *CQ VHF* magazine is the increasing variety of the uses of the VHF+ ham bands. What I brought to the position of editor of this magazine was my interest in weak-signal communications. During these past three years I have learned that there are other creative uses of the VHF+ ham bands besides weak-signal, amateur television, space, and FM communications. Thanks to you, our readers and authors, we have included articles on ballooning, HSMM, and DFing, as well as other fascinating aspects of VHF+ communications. No doubt, in future years there will be more major interests that also will expand the usage of the VHF+ ham bands, and I look forward to presenting these new interests in future issues of *CQ VHF* magazine.

Thank you for supporting the second rollout of *CQ VHF*. I look forward to the publication of many more issues of this, your magazine, in which I can continue to provide you with the venue for you to tell your fascinating stories.

Until the next issue…

73, de Joe, N6CL

QUARTERLY CALENDAR OF EVENTS

Contests

The **European Worldwide EME Contest 2005:** Sponsored by *DUBUS* and REF, the EU WW EME contest is intended to encourage worldwide activity on moonbounce. Multipliers are DXCC countries plus all W/VK/VE states. This gives equal an chance for stations from North America, Europe, and Oceania. The rules reward random QSOs, but do not penalize skeds on 2.3 GHz or above. Winners (1st place) receive a free subscription to *DUBUS* magazine.

The contest dates and bands are as follows: First weekend: 50 MHz, 1.3 GHz, 10 GHz, 24 GHz and up, 16–17 April, 0000–2400 UTC; second weekend: 144 MHz, 2.3 GHz, and 3.4 GHz, 14–15 May, 0000–2400 UTC; and third weekend: 432 MHz and 5.7 GHz, 11–12 June, 0000–2400 UTC. Sections and awards include the following: QRP 144 MHz <100 kW EIRP, 432 MHz <400 kW EIRP, 1296 MHz <600 kW EIRP, and >= 2300 MHz no separate QRP/QRO categories. The QRO category on 144, 432, and 1296 MHz, stations with EIRP equal to or greater than stated above. The PRO category includes non-amateur equipment or antenna. PRO stations will have scores listed separately. There are no separate multi-operator classes. Multi-operator and QRO stations will be highlighted in the general classifications. All QRP/QRO band winners and QRP/QRO multiband winners will receive a year's free subscription to *DUBUS* magazine. In each band/section, certificates will be sent to the top ten entrants and to the highest-scoring station in the southern hemisphere.

For a valid QSO, both stations must transmit and receive both callsigns + TMO/RST + R. During a QSO, on any band, liaison by any other means (e.g., DXcluster, Internet, telephone) is forbidden. There is no restriction on modes, but entrants must not cause inter-mode QRM.

Contest entries *must* be sent no later than 28 days after the end of the third weekend (i.e., in the mail or via e-mail by 10 July 2005). Mail address: Patrick Magnin, F6HYE, Marcorens, F-74140 Ballaison, France. You can also e-mail your contest entry in ASCII format to: <f6hye@ref-union.org>. All e-mail entries will be acknowledged within one week. For additional rules and general questions contact: <info@dubus.de>. Complete rules can be found at: <http://www.marsport.demon.co.uk/EMEcont2005.pdf>.

Spring Sprints: These short duration (usually four hours) VHF+ contests are held on various dates (for each band) during the months of April and May. This year's dates and times are as follows: 144 MHz, April 4, 7–11 PM local time; 222 MHz, April 12, 7–11 PM local time; 432 MHz, April 20, 7–11 PM local time; Microwave, May 7, 6 AM to 1 PM local time; and 50 MHz, May 14–15, 2300 UTC Saturday until 0300 UTC Sunday. Logs and summary sheets should be e-mailed or snail mailed to the below addresses. Logs should be submitted within 30 days of the end of each contest. Contact information: Jeff Baker, WU4O, 2012 Hinds Creek Road, Heiskell, TN 37754. E-mail: <springsprints@etdxa.org>. Sponsored by the East Tennessee Valley DX Association, further information on these contests can be found on website: <http://www.etdxa.org>. At this URL, click on the VHF/UHF link to get to the contest information.

The 2 GHz and Up World Wide Club Contest: The following is unofficial and was developed from assumptions based on last year's contest. Sponsored by the San Bernardino Microwave Society, this contest should run from 6 AM on May 7 to 12 midnight on May 8 (36 hours). The object is for worldwide club groups of amateurs to work as many amateur stations in as many different locations as possible in the world on bands from 2 GHz through Light. Rules are available at: <http://www.ham-radio.com/sbms/club_contest/2GHzUp.pdf>.

Quarterly Calendar

The following is a list of important dates for EME enthusiasts:

Feb. 2	Last Quarter Moon
Feb. 6	Very Poor EME conditions
Feb. 7	Moon Perigee
Feb. 8	New Moon
Feb. 13	Moderate EME conditions
Feb. 16	First Quarter Moon
Feb. 20	Moon Apogee. Poor EME conditions
Feb. 24	Full Moon
Feb. 27	Moderate EME conditions
Mar. 3	Last Quarter Moon
Mar. 6	Very Poor EME conditions
Mar. 8	Moon Perigee
Mar. 10	New Moon
Mar. 13	Moderate EME conditions
Mar. 17	First Quarter Moon
Mar. 19	Moon Apogee
Mar. 20	Vernal Equinox. Moderate EME conditions
Mar. 25	Full Moon
Mar. 27	Moderate EME conditions
Apr. 2	Last Quarter Moon
Apr. 3	Moderate EME conditions
Apr. 4	Moon Perigee
Apr. 8	New Moon
Apr. 10	Moderate EME conditions
Apr. 16	First Quarter Moon and Moon Apogee
Apr. 17	Moderate EME conditions
Apr. 24	Full Moon. Moderate EME conditions
Apr. 29	Moon Perigee
May 1	Last Quarter Moon. Moderate EME conditions
May 8	New Moon. Moderate EME conditions
May 14	Moon Apogee
May 15	Good EME conditions
May 16	First Quarter Moon
May 22	Moderate EME conditions
May 23	Full Moon
May 26	Moon Perigee
May 29	Moderate EME conditions
May 30	Last Quarter Moon

—EME conditions courtesy W5LUU

Conventions and Conferences

Southeast VHF Society: The society's 9th annual conference will be hosted in Charlotte, North Carolina, on April 29 and 30. The location will be the Hilton Charlotte Executive Park, 5624 Westpark Drive, Charlotte, NC 28217; phone 704-527-8000, fax 704-529-5963. Group rate is $75 per night. It is best to call the hotel direct and be sure to mention the Southeastern VHF Society Conference to get the discount rate. For more information about the hotel see <http://www.hilton.com/en/hi/hotels/index.jhtml?ctyhocn=CLTEPHF>.

Registration for the conference was not available at press time. Please check their website at <http://www.svhfs.org/registration_05.htm> for the registration forms.

Dayton HamVention®: The Dayton HamVention® will be held as usual at the Hara Arena in Dayton, Ohio, May 20–22. For more information, go to <http://www.hamvention.org>. Your editor, N6CL, is scheduled to be one of the speakers for the VHF forums.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers or for papers to be published in the conferences' *Proceedings*, or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. To date this year the following organizations or conference organizers have announced calls for papers for their forthcoming conferences:

The **Southeast VHF Society** (see conference dates announcement above): Contact Ray Rector, WA4NJP. Ray's e-mail address is <wa4njp@bellsouth.net>. The deadline for submitting papers is as soon as possible.

The 39th annual **Central States VHF Society Conference** will be held July 28–31 at the Sheraton Hotel, Colorado Springs. The deadline for submitting final papers will be around May 1. Submit your papers as soon as possible to Lauren Libby, WØLD, President, at <w0ld@pcisys.net>.

Meteor Showers

The *a-Centaurids* meteor shower is expected to peak around February 7 at 2245 UTC. The *?-Normids* shower is expected to peak on March 13 and again on March 17. Other February and March minor showers include the following and their possible radio peaks: *Capricornids/Sagittarids*, February 1, 0800 UTC; and *?-Capricornids*, February 13, 0900 UTC.

The *Lyrids* meteor shower is active during April 19–25. It is predicted to peak around 1030 UTC on 22 April. This is a north-south shower, producing at its peak around 10–15 meteors per hour, with the possibility of upwards of 90 per hour.

A minor shower and its predicted peak is *pi-Puppids* (peak around 1530 UTC on April 23). Other April and May minor showers include the following and their possible radio peaks: April *Piscids*, April 20, 0900 UTC; *d-Piscids*, April 24, 0900 UTC; *e-Arietids*, May 9, 0700 UTC; May *Arietids*, May 16, 0800 UTC; and *?-Cetids*, May 20, 0700 UTC; The above information is courtesy the International Meteor Organization and its website, <http://www.imo.net>.

Microwave Rain Scatter in the Upper Midwest

Borrowing from the song "The Rain in Spain Falls Mainly on the Plain," KMØT describes how the rain falls on the E-plane and H-plane of the microwave radiated signal and then re-radiates it to a new location. Hence, rain-scatter propagation.

By Mike King,* KMØT

Photo A. Left to right: A 9-element 144-MHz Yagi, 5.7-GHz dish, 10-GHz dish, and 18-element 70-cm to 432-MHz Yagi.

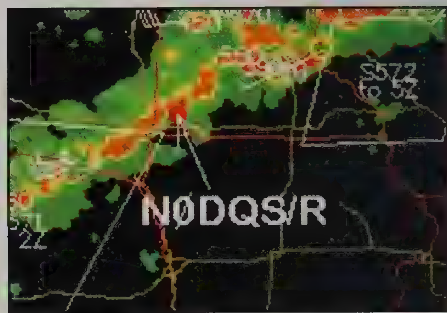

Figure 1. The arrow points to where Gene, NØDQS/R, was in a rain squall during the 2002 ARRL UHF Contest.

I had spent a number of months on the microwave bands without knowing that a very promising method of propagation existed. Through multiple contests and chasing rover Gene, NØDQS, it became apparent that 5.7 and 10 GHz were enhanced when we had rain in the area.

I wondered a bit about this and began to do some research on this particular propagation mode. With what I found, it was pretty much apparent that the guys in Europe probably laugh at us when we post our rain-scatter attempts and accomplishments, because this is a lot of their "bread and butter" propagation. There are some good articles on this mode by the European operators. There are also articles on 10-GHz rain scatter by Tom Williams, WA1MBA. A Google search of "European rain scatter propagation" will reveal a number of commercial and amateur radio references. For more on WA1MBA's articles, please see his website: <http://www.wa1mba.org/10grain.htm>. Also see his article "10 GHz, a Nice Band for a Rainy Day" in the February 1997 issue of *CQ VHF* magazine, as well as his paper "Narrow-Band 10 GHz and Some Observations from New England," which was published in the *Proceedings* of the 21st (1995) Eastern VHF Conference.

Working stations via rain scatter is not a hard thing to accomplish. In fact, I was working it without really knowing it. Now lots of the folks around the NLRS (Northern Lights Radio Society) area are "in tune" with this predictable propagation mode and are taking advantage of the potential it offers. You can get into the society's loop by subscribing to its reflector. Information on the NLRS, as well as instructions on subscribing to its reflector, are at <http://www.nlrs.org>.

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The Basic Theory Behind Rain Scatter

From what I gather from Tom, WA1MBA's article on this propagation mode, rain scatter is not a reflection, but really a "re-radiation" of energy. When signals reach a rain droplet of proper size in terms of wavelength comparison, then that particular droplet will "re-radiate" its energy to the next droplet, and then the next. This is a very simplistic explanation and, there is a great deal more behind it, but it does work!

Working the Mode Without Knowing It!

Chasing Gene, NØDQS, was one of my main efforts in the major contests (figure 1 and photo B). During the ARRL 2002 UHF contest I recall having great signals on 5.7 and 10 GHz without any explanation of why the standard forward-scatter tropo was better than it had been just shortly before the contest. I also made it

Photo B. KMØT helped NØDQS/R with the final installation of the microwave dishes prior to the 2002 UHF Contest.

a priority to watch the local radar for Gene, just to help keep him out of trouble from storms and such.

The particular grid he was in was not that far away, but signals were somewhat "auroral" on SSB and the radar confirmed that there was rain in the area. Gene had minor rain squalls all around him while he was in that area, but there weren't any around my home QTH. Signals were generally much stronger, and we chalked it up to just "dumb luck." I suppose this was based on observations of signal levels earlier in the day when things were dry and signals were in the noise. At that time we were just utilizing brute-force forward scatter at 100+ miles. We knew we could work these paths as long as we had the dish antennas pointed properly, but with rain in the area we had an easy time of it.

The nail in the coffin was when, on June 28, 2003, Gene made a grid expedition to EN42nx, which is in the southwest corner of Wisconsin (photo C). The purpose of his trip was so I could pick up that state for the Central States VHF Society's States Above 50 MHz contest. We were considering brute-force forward scatter or a bit of tropo enhancement to make our contacts.

The propagation situation turned out to be much different, though. I needed Wisconsin on 3.4, 5.7, and 10 GHz, so he had capability for all those bands. We found each other on 5.7 and 10 GHz on the direct path, but were having difficulty on 3.4 GHz. We both were running good power and antennas and utilizing superflex hardline feedlines, so we were disappointed when we were not able to make the path. The band simply was not open. My beam heading was very close to 90 degrees, due east, while Gene's was 270 degrees due west. With a bit of pointing around, however, I began to hear Gene, albeit weakly, and we managed to work with fairly strong signals. Again, the "auroral"-sounding CW/SSB was present.

A quick look at the weather map indicated that rain was present just to the north of the direct path. Gene indicated that he was hearing me pretty well when he pointed nearly 20 degrees north of the direct path. With that, I nudged my antennas a bit more to the north and he indicated that it made the signals even better. It was about that time when Gene noticed he could see some black clouds off in the distance to the northwest. As it turned out, I ended up being pointed at 82 degrees while Gene was pointed at 315 degrees. He was nearly 45 degrees off direct heading! We ended up chatting on SSB with 5×3 to 5×4 signals.

That information led me to quickly check the local radar map on the Internet. It was evident that rain scatter was the reason for the contact. Going back to direct path resulted in no signals heard.

We did not know it at the time, but a distance record for 3.4-GHz rain scatter had never been recorded for the band, so we submitted that later to get a spot on the DX record page! The direct-path distance of the contact was 435 km (270 miles).

We never thought to point the 5.7- and 10-GHz dishes on that path. If we had, the signals could have been much better. However, I had Wisconsin in the book and that's what mattered at the time.

Photo C. NØDQS operated portable from Wisconsin, EN42nx. Note direct heading for the dish and skew path to the north for the 3.4-GHz looper antenna. The minor precipitation clouds can be seen in the distance.

(Continued on page 77)

Patience Pays Off

Tulsa Air and Space Museum ARISS Contact

Thanks to NASA, there have been more than 150 educational-related amateur radio contacts with the International Space Station and the space shuttles. Each of them has been inspirational for the participants. In this article W5IU recounts one of the more recent ones, which took place in Tulsa, Oklahoma, as a way of encouraging other educational groups to also participate in the ARISS program.

By Keith Pugh,* W5IU

After a two-year wait and one "false start," a successful ARISS (Amateur Radio on the International Space Station) contact was made between the students of the Tulsa Air and Space Museum (TASM) Space Camps and the astronaut and cosmonaut on board the International Space Station. The contact took place at 9:12 AM on 22 December 2004 from TASM.

Nine students asked two questions each and received full replies from ISS Commander Leroy Chiao, KE5BRW, on board the ISS. Katheryn Pennington, the museum's executive director, asked an additional question, and Season's Greetings were passed on to the ISS crew during the nine-minute QSO.

The nine students who participated were William Bloomfield from Thoreau Demonstration Academy, Tulsa; Wyatt Bonicelli, from Pratt Elementary, Sand Springs; Ryan Darrow, from Holland Hall, Tulsa; Chelsie Downie, from Emerson Elementary, Tulsa; Lawrence Ross, from Victory Christian, Tulsa; Chase Karnstadt, from Austin, Texas; Robert Nolan,

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Students in queue waiting their turn to speak with ISS commander Leroy Chiao, KE5BRW, during an ARISS event at the Tulsa (Oklahoma) Air and Space Museum. (All photos courtesy N6CL)

Harry Mueller, KC5TRB, makes adjustments on the still partially working console originally used by NASA in its space program.

Author Keith Pugh, W5IU, awaits acquisition of signal (AOS) from the International Space Station in preparation for the TASM ARISS QSO. Note that the call on the sign is the club call of the Tulsa Repeater Organization and was the callsign used for the TASM QSO event.

Group photo following the TASM ARISS QSO. From left to right, rear: Lawrence Ross; Harry Mueller, KC5TRB; Bill Griffin, NI5X; Ryan Darrow; Mark Conklin, N7XYO; Lauren Olten; Keith Pugh, W5IU (face hidden); Robert Nolan; Katheryn Pennington. Left to right, front: William Bloomfield, Chelsie Downie, Kyler Swearingen, and Wyatt Bonicelli.

from Foster Middle School, Tulsa; Lauren Olten, from North Intermediate High School, Broken Arrow; and Kyler Swearingen, from Marquette Private School, Tulsa.

Observing the contact were four students and their advisor from Hamilton Middle School: Shanekah Jones, Leo Alexander, Quiara Scott, Shayla Bethel, and Ms. Rita Balleu.

Preparations for the ARISS QSO started with an application made to the ARISS Program via the ARRL more than two years ago. The contact initially was scheduled for June 2004. Unfortunately, a high-priority "Space Walk (EVA)" came up at almost the last minute and caused a re-scheduling for the week of 20 December. Final preparations resumed in November 2004, leading up to the contact. No equipment was available at TASM to support the contact at the museum, so the Tulsa Repeater Organization (TRO) and others provided equipment for the contact.

Two representatives of TRO who were instrumental in arranging the details of the contact were its president, Mark Conklin,

Pictured are the cross-polarized antennas used for the TASM ARISS QSO. They are mounted on a 40-foot communications tower that was loaned to TASM by Mobile Equipment International.

TASM Questions Asked of Commander Chiao

1. Lawrence: Do the G-forces from leaving the Earth's atmosphere cause you to have little red spots on your face that we kids call G-measles?
2. William: How much of the International Space Station is complete and what is the expected life (of the station)?
3. Chelsie: What does one day in the space station look like?
4. Chase: Is it hot or cold up there?
5. Ryan: What do you think the benefits are of civilian space travel? Do you foresee civilians ever visiting the ISS?
6. Kyler: Has any space junk or meteor pieces ever hit the space station?
7. Robert: How is the physical training different at NASA than from the military?
8. Lauren: What would your advice be for an aspiring astronaut?
9. Wyatt: Can you see storms that happen on Earth?
10. Lawrence: Do you have to use parachutes to slow down after going through the Earth's atmosphere to land?
11. Ryan: What is the physical impact of a zero-gravity environment on you over a long period of time and how do you deal with this when you return to Earth?
12. William: What is the scariest or most dangerous thing that you do?
13. Lauren: Is it worth all the time, effort, et cetera, to become an astronaut?
14. Robert: What is it like working with someone from another country for a long time?
15. Chelsie: What kind of foods do you like to eat in space?
16. Chase: What do you do for exercise?
17. Kyler: What has been the most interesting experiment you have gotten to work on in the station?
18. Wyatt: Is it fun floating and how does it make your body feel?

Ms. Pennington asked: As you are looking out the space station right now, what do you see?

Left, Lawrence Ross, a fifth-grade student at Victory Christian School, Tulsa, asks a question of ISS Commander Leroy Chiao, KE5BRW, while Bill Griffin, NI5X, controls the earth station at the Tulsa Air and Space Museum.

Other students were invited to be observers of the TASM ARISS QSO. From left to right are Hamilton Middle School students and their advisor: Shanekah Jones, Leo Alexander, Quiara Scott, Shayla Bethel, and Ms. Rita Balleu.

TRO president Mark Conklin, N7XYO, being interviewed by one of the local photojournalists.

N7XYO, and Bill Griffin, NI5X. Also working to make the contact a success were TRO members Ed Compos, K5CRQ, and Harry Mueller, KC5TRB. TRO's website is <http://www.TulsaHamRadio.com>. In addition, I served as ARISS's required mentor for the contact. For the QSO, Bill served as the control operator, while I made sure that the radios functioned properly.

Two complete stations were assembled. The primary station consisted of a Hy-Gain circularly polarized Yagi, an Advanced Receiver Research (ARR) RF switched GasFet pre-amp, and Yaesu G-5500 Az-El rotators on a portable tower driven by a Yaesu FT-847 transceiver, LabJack/LabJack Piggyback Rotator Interface, and Nova tracking software. Tulsa's Mobile Equipment International loaned a 40-foot communications tower to TASM for the antennas.

Doppler correction of both the uplink and downlink was done in the FT-847 by storing multiple frequency pairs in memories and selecting these appropriately. This may seem like "overkill" to work the ISS, but it is necessary to maximize the contact time. Every effort was made to construct a station capable of communicating with the ISS from "horizon to horizon."

To take care of "Murphy," a secondary station was assembled. This station was not capable of "horizon to horizon" contacts. It consisted of a simple vertical antenna, an FT-897 transceiver, tracking software, and battery power. While not as capable as the primary station, the secondary station was very simple and not as dependent on technology.

All of the equipment was brought together, assembled, and checked out the day before the contact. Students were briefed ahead of time on the procedures to be followed during the contact. "Dry runs" with the students were not possible due to the varied Space Camp backgrounds of the students. "Dress rehearsals" were accomplished just before the contact on the morning of the event.

Everything went well during the contact, and the secondary station was not utilized. All of the efforts were rewarded by the smiles on the faces of the students, parents, and other observers. It is likely that a seed was planted in at least one or two students to pursue a career in the sciences or engineering, and, who knows, one of them may fly as an astronaut in the future. For more information on your school or organization supporting an ARISS QSO, please visit the AMSAT website at http://www.amsat.org/amsat/ariss/news/arissnews.txt>.

In commenting on the ARISS QSO, TASM's executive director, Katheryn Pennington, said, "Statistics prove learning and retaining knowledge improve for children when they are personally involved. The radio linkup will broaden their horizons, giving them a new perspective of space living and exploration. Teachers can expand this experience by relating it to science, geography, history, and physics. Children can explore the relationship of life on Earth and how it compares to life in space."

TASM is located in one of the original Tulsa Municipal Airport hangers, provided to TASM courtesy of Spartan College of Aeronautics and Technology. Within the museum are displays of actual aircraft and mockups of aircraft and space vehicles used for air transportation and exploration. TASM is scheduled to move to a new 25,000-square-foot facility late this summer. TASM annually holds a summer camp that instills self-confidence and self-reliance in young students by exposing them to traditional and non-traditional fields of work through supporting their interest in math, science, and technology. For more information on the mission of TASM, visit its website at: <http://www.tulsaairandspacemuseum.com>. ■

Rover Flagpoles

One of the problems of rover operating is getting the antenna in the air effectively and safely. Here WB6NOA provides the solution—telescoping flagpoles.

By Gordon West,* WB6NOA

A serious VHF/UHF rover may have a tilt-up tower to get the aluminum up in the air. I admire that, and I marvel at the ingenuity that goes into these exotic tower systems permanently welded to the vehicles. Less serious VHF/UHF rovers have an affordable alternative, though, thanks to the RV industry—the telescoping flagpole and trailer-hitch-receiver lay-down mount. The limitation is the amount of aluminum you can manage aloft with the flagpole extended. However, this is an antenna elevation system that doesn't require any major vehicle modification, which is something your significant other may appreciate.

Don't run right out and buy a flagpole from the local RV store. I have found out that there are some big differences in how telescoping flagpoles work. When you are struggling to push up a couple of long-boom beams, the last thing you want is the wrong kind of flagpole, one which just won't stay extended easily when the wind begins to blow.

Two of the largest flagpole manufacturers are Uncommon USA (http://www. uncommonusa.com) and Sunsetter (http://www.sunsetter.com). I have a flagpole from each. You can choose from a variety of flagpole colors: silver, bronze, white, and black. Also, there are some subtle differences that are important to those of us who place a long-boom antenna on the top of a flagpole as opposed to Old Glory. Because both manufacturers are continuously refining their flagpole offerings, here are the most important things to look for when shopping for flagpoles at an RV superstore.

Flagpole Features

How Tall? Sixteen-foot telescoping flagpoles are available, but why not get an extra 4 feet for a few more bucks and go for 20 feet? However, going to 25 feet may create the "noodle effect," as Chip Margelli, K7JA, calls it. You don't want the top section to get "goosey" under the load of a big antenna and begin to sway erratically. Stay with 20 feet, and a long-boom antenna won't normally "noodle" the entire pole.

Easy Lockers. Examine how each telescoping section locks in place. Usually there is a spring-loaded pin that pops out to securely lock the sections in place. Carefully examine the locking pins to ensure there is no way the pin might not make a positive contact to keep the upper section up.

Guide Tracks. The Sunsetter flagpole comes with the guide tracks on the inside. The Uncommon USA pole that I own appears *not* to have the tracks. The guide tracks keep the spring-loaded, push-out buttons and their associated lower section holes exactly in line. As you raise the pole with the antenna on top, you want to make sure you don't pull the upper pole out beyond where the pin should pop through the lower hole. I believe both manufacturers have some sort of safety catch to keep you from accidentally raising an upper section to the point

The telescoping flagpole goes up in minutes! (Photos by the author)

**CQ VHF Features Editor, 2414 College Dr., Costa Mesa, CA 92626 e-mail: <wb6noa@cq-vhf.com>*

The flagpole will hold some large VHF and UHF antennas without "noodling."

where it actually pops out of the lower mast, causing the whole assembly to fall.

I have nightmares about going beyond where the pin should make contact and pulling the pole all the way out of the lower section. To make absolutely sure this doesn't happen to me, I have felt-tip-marked big countdown numbers on the inner sections that read 5-4-3-2-1-stop to let me know how close I am to hearing the pin spring into the lower section hole. With the Sunsetter pole, the guide keeps the pin and holes perfectly aligned for an every-time snap. However, with the Uncommon USA flagpole, when I get to the "stop" mark I then have to turn either the upper or lower pole until the pins engage.

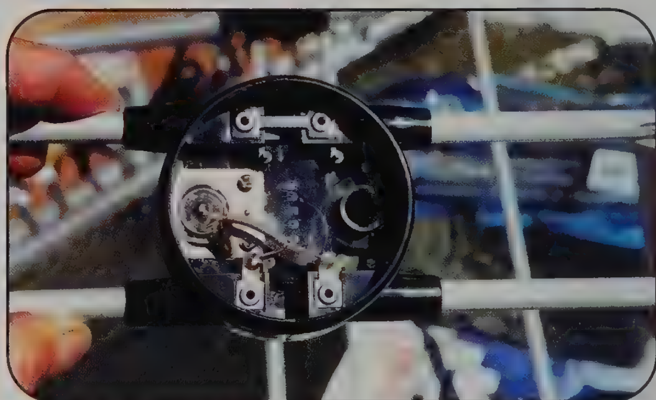
If you plan to use the poles as an integral conductor—such as a hidden vertical antenna on your front lawn—you usually will need to add your own jumpers between each section, because Uncommon USA uses polycarbonate bushings, which allow each section of the pole to slide up and down smoothly, but specifically where metals never touch.

If the raised antenna is not so large as to "noodle" the pole, go ahead and fly a flag at the top with the supplied rope and pulley.

Ground Sleeves. Both of these flagpole companies, and I am sure a lot of other telescoping-flagpole manufacturers as well, also supply vehicle ground mounts. The one I like best is the hitch mount, which slides into your vehicle's trailer-hitch receiver. It usually includes a PVC tube that will keep the flagpole perfectly snug on the hitch mount. Depending on which flagpole

The yellow paint on the fold-up MASPRO antenna is for element centering.

The MASPRO antenna elements swing out and are centered on the yellow mark.



The feedpoint on this MASPRO UHF antenna needs the coax swapped to RG-58AU.

you order, the company will supply the right diameter sleeve. The hitch mounts will still have a little left-to-right wobble, but this is to be expected; the antenna will still stand tall, even though there may be a 5- or 10-degree list to your entire system.

Another type of stand to hold up telescoping flagpoles is the aluminum-wheel stand. Just drive over the stand and you are all set. These work well and actually have less wobble than the trailer-hitch stand. The only drawback of the aluminum-wheel stand is the big bend you will put in the bottom plate when you park on dirt and the heavy weight of your vehicle distorts the flat surface. In future mountings the pole will now lean slightly in toward your vehicle. This actually can be a good thing, as

your vehicle can help steady the pole if you jam a big pillow in between the leaning pole and the side of your vehicle.

Direction and Height

The whole idea of the mobile telescoping flagpole is to get the antenna two or three wavelengths above the ground. This means you don't necessarily need to extend the smallest inner section on which the beam is mounted. If your pole has a channel, the beam will stay aimed based on however you adjust it down at the base. If the pole has no channel to hold the uppermost pole in place, the wind will immediately change the direction in which your beam is pointed.

During a recent rover VHF/UHF contest, I saw a group of hams down by the highway struggling for hours to get their 35-foot, telescoping non-flagpole up in the air with a beam on the top. What a job! I merely drove up a little dirt road onto a gentle rise, and presto! All the way there, my beam on the flagpole was 50 feet higher than theirs was swaying in the breeze. It is easier to gain height by driving to a high spot than by struggling at a lower elevation trying to get a big beam on a skinny pole way up in the air!

MASPRO Antenna

An interesting antenna manufactured by MASPRO Antennas offers good gain and minimum weight. Better yet, the aluminum elements loosen up with a thumbscrew, turned parallel to the boom, and can slide in and out so the elements nestle to the boom such that they do not extend beyond the boom. The boom also separates in the middle. This is the antenna seen in the accompanying photos of the communications van and my "high site" during a contest last fall. It takes only minutes to fold out and adjust the elements into position, and the whole antenna for either 145 or 440 MHz easily fits into the van's side locker.

A few dealers may currently stock MASPRO antennas for immediate shipment to you, or they can be ordered through your local dealer, which will take the time to bring them in special order from Comet/NCG Company (1275 N. Grove St., Anaheim, CA 92806; telephone 800-962-2611; <www.natcommgroup.com>). The collapsible 2-meter or 440-MHz MASPRO beam is imported from Japan. I suggest opening up the plastic balun and replacing the RG-174 coax with RG-58AU, thus providing 160-watt capabilities.

Finally, the cost of the flagpole and the associated mounts is about $275 plus $50, respectively. Hitch-receiver mounts are about $95. Once you have the system, you can almost instantly park your vehicle, mount an antenna atop the flagpole, and inch the flagpole up into position for a quick VHF/UHF contact. Just be sure to avoid high-voltage wires (see below) and you will be all set!

Warning!

Watch out for power lines! The metal flagpole contacting the power lines can kill you. Post a sign on the steering wheel that says your flagpole is up. You do not want to drive away with the flagpole raised. If it is on a wheel stand, as soon as you drive off the wheel stand it will come crashing down, causing major injury to anyone around and the death of your beam. If you drive around with the flagpole up, you instantly will become a fried ham as soon as you hit an overhead power line.

The PJ7M 6-Meter Expedition

This past summer, K4BI and K2ZD went on a DXpedition to Dutch Sint Maarten to take advantage of 6-meter sporadic-*E* propagation. Read all about it . . .

By Jim Holt,* K4BI

Once one enters the main portal of amateur radio as a hobby interest, the number and variety of specialty interests within it are numerous and varied. One of these is described as 6-meter DXing, which enjoys a relatively small but active number of individuals. An even smaller subgroup within this specialty interest is those who enjoy and actively make trips to entities around the globe in order to activate them for the express purpose of making them available for 6-meter QSOs.

Mario Karcich, K2ZD, and I are members of this subgroup, and while attending the Jimmy Treybig,W6JKV, annual 6-meter Bar-B-Que party in September of 2003, we talked about and basically committed to going to Dutch Sint Maarten in the Caribbean during early July of 2004 for this purpose, providing a suitable site could be located and arranged. Early July has become the preferred time frame for efforts such as ours, because the growing body of experience with 6-meter propagation during this period suggests that it is a "prime time" for long-haul openings that don't relate to the 11-year solar cycle.

We had observed this during our very first trip together back in July 1988 (PJØM on Saba Island). Region 1 had, for the most part, permitted 6 meters just a few years earlier, and no one had any serious expectations that non-*F2* long-haul contacts would take place. We made lots of contacts with North America while there, but the real surprise was that 48-MHz video carriers from Europe were heard every day and for hours at a time. It was during these periods of video-carrier reception that we completed three QSOs with two stations in the U.K. and one station in Portugal on 6 meters—a real harbinger of things to come.

Jim, K4BI, and Mario, K2ZD, on the villa balcony in Dutch Sint Maarten. (Photos courtesy the author)

Dutch Sint Maarten

This was our third trip together (the second was to Barbados in 2000), and use of the internet for the purpose of searching out a proper site and then completing arrangements has made this part of the job considerably easier in terms of time and effort required.

Our site was Villa Arcadia, a private home located at the extreme eastern end of the island and overlooking the sea from an elevation of 800 feet ASL. Having secured the location, Mario—who had obtained the special PJØM callsign from Landsradio, the controlling agency in these matters for all of the Netherlands Antilles—again requested a special call, and was awarded the callsign PJ7M.

Setting up the rest of the trip was pretty straightforward and most aspects of the trip were in place by springtime. Since Mario (and his XYL Daphne, N2TIN) were traveling from the New York City area, and Meredith, K8BBN (my XYL), and I were traveling from Atlanta, it wasn't practical for us to arrive at the same or even close to the same time. Since they arrived several hours earlier than we did, they picked up the rental vehicle, made arrangements for us to be picked up on arrival, and went on to the site.

When Mario arrived at Villa Arcadia, he conducted an immediate search for our antenna, which had been shipped earlier. Not finding it quickly and suspecting that the band just might be open, he proceeded to erect the portable dipole he had brought with him (primarily for HF communication, but usable on 6) and began tuning around with just the barefoot FT-100 transceiver he'd brought along. Sure enough, the band was indeed very much open, and he immediately began making contacts. When my XYL and I arrived at

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The portable dipole for Mario's first contacts as PJ7M.

the site, he was still very busy working stations in Europe, North America, and the Caribbean!

I quickly found and began to assemble our 6-meter Yagi, aiming to get our planned "big" station running (our "big station" ultimately consisted of a Yaesu FT-100 with a modified Dentron Clipperton V amplifier using an 8930 tube instead of the original 4CX250B tube; the antenna was a 6M5X Yagi by M^2). This was all well and good, until the carton was opened and I discovered that a key component (balun) was missing! A quick scan of the Sint Maarten telephone directory showed there to be a supplier of the needed components, but since it was already dinner time and the store had closed, we elected to continue with what was working. By the time the band opening ended, it was nearly 10 PM local time. A quick look at the log showed that PJ7M had already worked some 168 QSOs in 28 DXCC entities. Wow!

When we awoke the next morning (very early), the band was once again open, and we continued operations with the "small" station, planning to head for Phillipsburg as soon as the band closed to obtain what we needed to complete assembly of the beam. During the morning I was able to speak with Mort Bardfield, PJ7UQ, on the PJ7R repeater, and I explained our predicament. Mort indicated that he'd be near his handheld most of the day and would direct us to the electronics store.

Before heading out, we were further surprised when Mort called us on 6 to work us, and in the process he indicated that this was his first ever 6-meter QSO! He was using a transceiver he had at his home station, which included 6-meter capabilities, loading it into his HF tribander.

Shortly after this, Mario and I headed into town, aided by Mort's directions, to get our coax balun material and connectors. When we arrived at the store (shortly after 1 PM), we were sadly disappointed to find that the store had already closed for the day, leaving us faced with the likelihood that we'd be unable to get the beam finished for another day and a half. Very fortunately for us, PJ7UQ directed us to his office, not far from the electronics store, because he just happened to have what we needed. We met Mort and his son Ed, PJ7ED, who provided the needed materials.

Upon returning to our QTH, I was able to complete assembly of the antenna, erecting it with Mario's help. Then, while Mario continued to watch 6 meters with the dipole/transceiver combination, I assembled our planned station in a spare bedroom. We finally got on the air with it on Saturday evening, July 3rd. Our plan was to have the station on the air from very early in the morning each day until late in the evening, and one of us would be present at all times during these periods. This really worked out well. When the band opened, Mario or I would be summoned to assist. It should also be noted that we'd arranged for Internet access by dial-up telephone, but weren't able to use it until Monday afternoon, July 5th due to a problem with the telephone. We have to offer apologies to those on the chat pages who wanted to exchange comments, etc. We were just too busy to spend much "chat" time.

The 48.25-MHz video carrier (which we assumed was from Navacerrada, Spain) was a most reliable indicator of propagation to Europe. We made it a point to check that frequency regularly, and every time it came up out of the noise, QSOs with EU stations followed soon after that. When we were working that continent, the area favored was primarily the U.K. and west central Europe, but it constantly moved around, permitting QSOs with Scandinavia, the Mediterranean, as well as eastern Europe.

North American openings clearly favored the eastern half of the U.S. and Canada, with only a small number of contacts west of the Mississippi. There were periods every day when no amount of calling produced contacts in that direction, yet upon our return we were told by several individuals in widely divergent locations that they had copied our beacon signal for hours at a time (while making no contacts)! An inspection of our log

The 6-meter Yagi set up on the balcony.

shows that the directivity of the propagation sometimes wasn't very narrow. There were periods when we were working many European stations one after another, but these were interspersed with North American stations calling and working us during the same opening even though our antenna was pointed to favor EU.

The duration of the opening varied from day to day, with some openings lasting only 2 to 3 hours, while others lasted nearly 12 hours.

The daily band openings (yes, the band opened every day) featured signal levels varying from just audible to very loud. We were able to copy the weak signals well because the expected power-line noise and CATV birdies just weren't present. From my personal experience over nearly 50 years on the 6-meter band, this was the quietest location from which I'd ever operated.

Our operating plan was to run the beacon keyer to attract attention, which worked well. We stayed primarily on CW, but when conditions permitted and the requests came, we did operate SSB. We did some split-frequency operation for sideband contacts with better success than we had achieved during our trip to Barbados in 2000. To minimize the QRM in the pile-up, Mario and I both think this technique may become more prevalent during future 6-meter expeditions.

While this trip was a lot of hard work, we had a blast doing it. If you thought you had fun working us, you should have heard us holler when we'd work a new entity! The culmination of the operation came on Sunday afternoon, July 11th, when we completed a contact with Nick, 5B4FL, after what seemed like forever, going back and forth on the QSB peaks to get it done.

In general, signals levels varied from 599 to 219 on CW and 59+ to 2×1 on SSB. There were some periods when QSB was rapid, other extended periods when signals remained quite strong, and then other periods when signals were quite weak.

The Results

The final result of our trip was 1150+ QSOs and 45 distinct DXCC entities, with all contacts made on 6 meters! Further breakdown of the contacts revealed 613 QSOs with Europe, 536 QSOs with North America, along with one African and one Asian QSO.

The sole African station worked was 5T5SN when I was operating the "small" barefoot station with the portable dipole antenna Saturday morning before we headed out to obtain parts to build the balun for the beam. No other stations were audible at the time in the receiver. He just came up on our frequency and dropped in his call, and we completed with 559 reports both ways. I kept calling, but didn't work anyone else for the next hour and then we went QRT to drive to Phillipsburg.

The big disappointment was that while the QTH gave us a clear shot over the ocean for the European path, with only minor obstructions for the North American path, there was another 250 feet of hillside behind us, which eliminated the ability to do well to South America and Caribbean islands to our south. Because of this hill only three stations were worked to our south or southwest—J79KV, FM5WD, and HP2CWB. The farthest west QSO was a toss-up among the states of Texas, Oklahoma, and Nebraska. Bob, K6QXY, did tell us at the W6JKV party in September that he had heard our beacon keyer on a couple of occasions, but didn't call since he had already worked PJ7!

The big station—a Yaesu Ft-100 with a modified Dentron Clipperton V amplifier.

Our Thanks

Mario and I are indebted to Mort and Ed Bardfield for their immediate, unconditional offer of help and friendship, and to our wives Daphne and Meredith for keeping us well fed,

We also thank Landsradio for the special PJ7M callsign; certainly all of you we worked; and last, but not least, Mother Nature, for providing us with wonderful propagation during our stay.

Hopefully we were able to put a dent in the "I need PJ7" numbers. To further that end, we left our antenna with Mort (who was quite impressed after hearing of our results), who promised us he'd put it up and try to provide some regular presence from Sint Maarten on 6 meters. ■

Mario, K2ZD/PJ7M, working the DX pileups.

Some Notes on Crystals and Oscillators

What is inside that container called a crystal? On what frequency does that crystal oscillate? Here KØVXM discusses some of the basics of crystals.

By Chuck Hoover,* KØVXM

Oh, Happy Day! The crystal you ordered for your latest pet project finally arrived. Deftly, you install it. Confidently, you apply power. Smugly, you measure it with your Radio-Shack counter. Oh . . . oh (or worse), you discover that it's oscillating, but it's not on frequency. In fact, it's a long way off! Before you fire off an angry e-mail to the crystal supplier, pour a cup of coffee and read on.

First, the following remarks apply only to thin, flat, round AT-cut plates with deposited electrodes, which are designed for oscillator service and mounted in conventional holders (see photo A). This means that I will be discussing crystals with frequencies above about 10 MHz, thus encompassing a large majority of crystals.

Second, I will not delve into the realm of mathematics. Some math is unavoidable, of course, but a four-function calculator will handle everything nicely.

Figure 1 is the equivalent circuit of a crystal. *C, L,* and *R* are the representations of motional capacitance (very small), motional inductance (very large), and resistance (generally small). The motional capacitance is expressed in femto Farads (10^{-15}), or thousandths of a pico Farad. The motional inductance is expressed in Henries. Because the resistance is generally less than 100 ohms and the reactance of the motional elements is quite high, the Q of the crystal is also high. The term *Co* is the capacitance because of the electrodes, the holder, and the mounting structure (see photo B).

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This capacitance is generally between 3 and 5 pico Farads. This is a "real" capacitance. Simply insert the crystal into capacitance meter and read the value.

Crystals can be run on their fundamental frequency and odd overtones (third, fifth, seventh, etc.). The overtones are close to, but not exactly, the integral multiple of the fundamental. The values of the motional elements change with the overtone of operation. For example, a crystal operated on the fundamental overtone may have a motional resistance of 10 ohms and a motional capacitance of 30 femto Farads (see note 1), while the same crystal, running on the third overtone, will have a motional resistance of 30 ohms and a motional capacitance of 3.3 femto Farads. When it is operated on the fifth overtone, the resistance will increase to 50 ohms and the capacitance will fall to 1.2 femto Farads. On the seventh overtone, the resistance will be 100 ohms and the capacitance will be 0.6 femto Farads.

It is possible to excite crystals on higher overtones (ninth, eleventh, etc.) However, the resistance becomes so great that the oscillators become difficult to start, or will take off and run at some frequency not under crystal control. A few years ago, seventh overtone operation was included in this category.

Figure 2 shows a plot of reactance versus frequency for a typical crystal. We see point *S,* which is the series resonant frequency, and point *A,* which is the parallel, or anti-resonant, frequency. The difference between these frequencies (known as the pole to zero spacing) is also overtone dependent. For example, a fundamental overtone crystal might have a resonant to anti-resonant spacing of 1500 parts per million. While operating on the third overtone, the spacing would be about 170 PPM. Operating that crystal on the fifth overtone will yield a spacing of 60 PPM, and on the seventh overtone the spacing drops to about 30 PPM. What this tells us is that as the overtone increases, the pullability decreases dramatically.

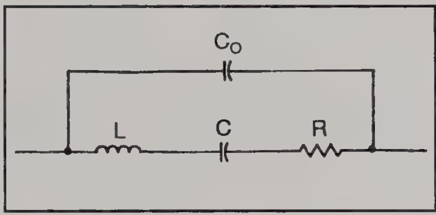

Figure 1. Equivalent circuit of a crystal as illustrated by capacitance, resistance, and inductance.

In the lab we can measure the true series resonant frequency very easily, and the true anti-resonant frequency with some difficulty. In practice, the true anti-resonant frequency is not particularly useful, but the region around series resonance is where virtually every crystal oscillator operates. Series resonance is the frequency at which the phase shift is zero and the resistance is at minimum. A simple fixture for measuring crystal frequency is shown in figure 3 and photos C and D. The most accurate way of using the fixture is to connect a vector voltmeter to terminals *A* and *B*. However, a dual-trace oscilloscope can be used, which, with care, can yield surprisingly accurate results.

Anti-resonance can be measured in the same fixture. However, one must tune very carefully, because the anti-resonant frequency is elusive and things happen in a big hurry. Anti-resonance is better

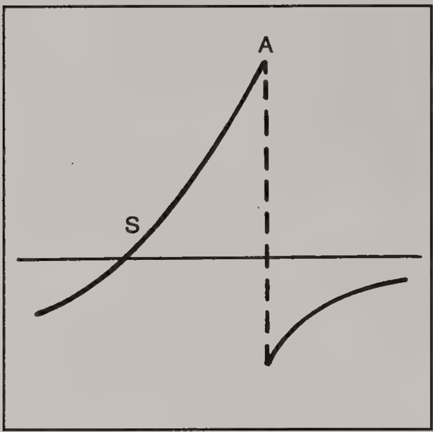

Figure 2. A plot of reactance versus frequency for a typical crystal.

found by measurement of the 45-degree phase shift, and then calculation of the anti-resonant frequency.

Photos E and F show two instruments used for production testing of crystals. These meters agree with the standard fixture described above to with 0.5 PPM at series resonance.

If we have an oscillator that is running at series resonance and if we insert a capacitor of 32 pF in series with the crystal, the oscillator will move up in frequency. If we then change the capacitor to a value of 10 pF, the oscillator frequency will move even higher.

Crystal manufacturers refer to this capacitance as the *load capacitance.* Values of 10 pF, 20 pF, and 32 pF are standard values of load capacitance. The use of the term *load* is deceptive in that the capacitor is really a resonance compensation element and is used to match the characteristics of the crystal to the characteristics of the oscillator. It is this change in frequency versus change in capacitance (referred to as *trim sensitivity*) that allows temperature compensation and oscillator disciplining. Also, Direct FM and FSK can be accomplished.

If we use a variable capacitor in place of the fixed capacitor, we can adjust the oscillator frequency about anywhere we want. In the case of a fundamental overtone crystal, we can move the frequency a remarkably long way—easily several hundred parts per million.

The astute reader will ask, "Can we replace the capacitor with an inductor and get the frequency to move lower?" In short, yes, with results similar to, but opposite in frequency to, the use of a capacitor.

There are limits to how far we can pull the frequency, however. The upper limit is obviously nearly the anti-resonant frequency. The lower limit is where more inductance yields insignificant changes in frequency or the impedance of the inductor becomes large enough to prevent oscillation.

Many of you will have heard that pulling the crystal from its design frequency will degrade the oscillator's stability. This is not true, if one only uses the series inductor or capacitor to cause the frequency change. In fact, by judicious selection of the series component, one can actually enhance the stability of the system.

Figure 4 shows crystal frequency change versus temperature by rotation of the crystal axis in minutes of arc. Crystal manufacturers use this data to select the angle that best suits the customer's requirements. For example, a requirement for ±10 PPM stability from –20°C to +70°C would call for angles between +2' and +5'. A requirement for service in an oven operating at +85°C would need an angle near +12'.

The absolute value of this angle is dependent upon many factors. The primary factor is the overtone of use. A 0'-angle crystal operated on the fundamental will not be anywhere near the 0'-angle curve when operated on a higher overtone. It is this phenomenon that primarily precludes the use of a crystal designed for fundamental service on higher overtones. Other design factors also differentiate fundamental and overtone service. Generally, though, it is not good practice to use crystals on overtones other than that for which they were manufactured.

An important but often overlooked consideration is that of drive level. Most crystals are specified to operate at a drive level of 1 mw. Many things can happen when crystals are over driven—all bad.

As the drive level is increased, so-called "spurs" may appear. These are mechanically coupled modes that are excited by the excess movement of the quartz blank. The good part is that when the drive level is reduced, these coupled modes disappear.

Excessive drive can also cause an increase in the aging (we will discuss aging later) rate of the crystal. It is also

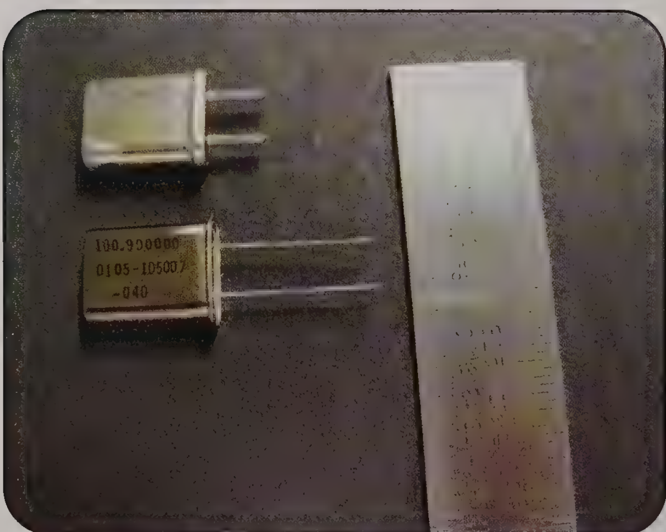

Photo A. Examples of crystals mounted in conventional holders. (Photos and graphics by Ivars Lauzums KC4PX)

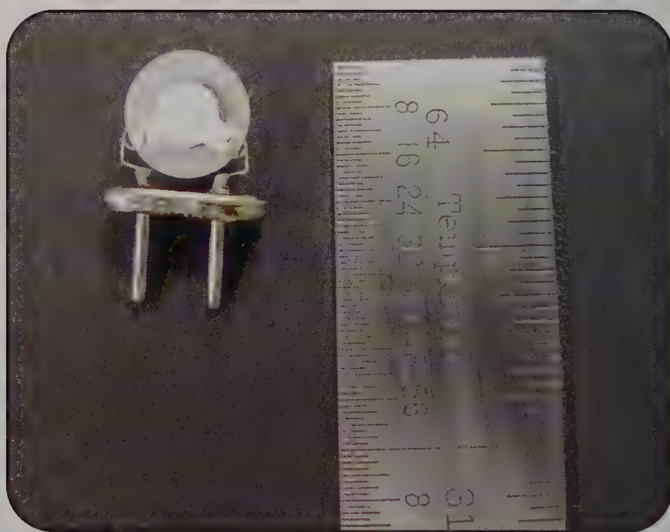

Photo B. A crystal mounted in a conventional holder with the cover removed.

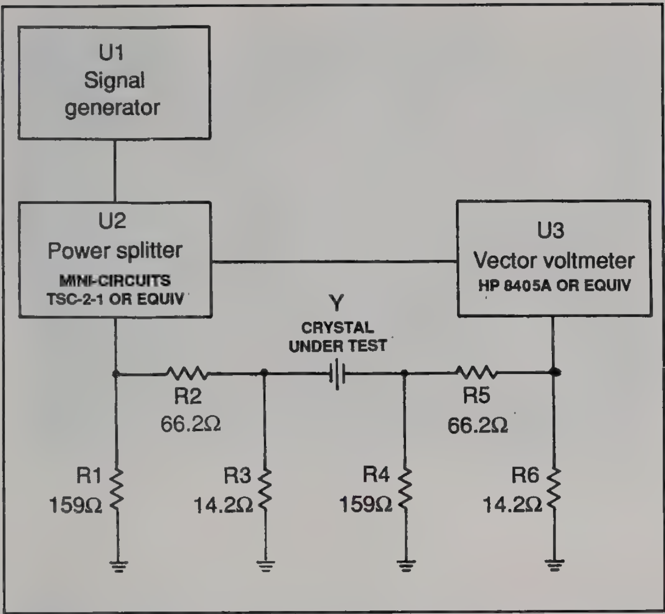

Figure 3. The schematic diagram for a simple fixture for measuring crystal frequency.

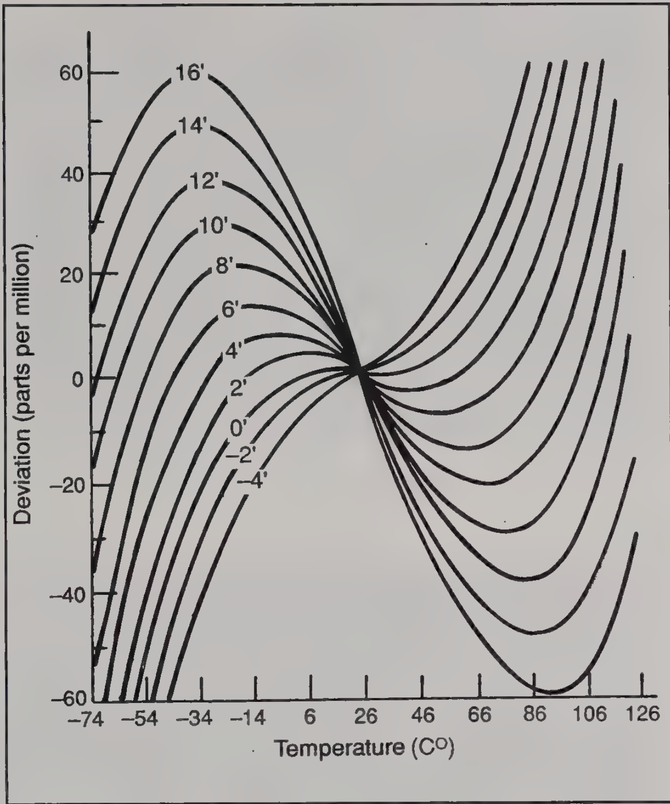

Figure 4. A graph illustrating crystal frequency change versus temperature by rotation of the crystal axis in minutes of arc.

quite possible to destroy the crystal by excessive drive. The electrodes can be blown off the quartz blank (been there, done that), or the blank itself can be fractured (been there, done that, too).

Drive level can be measured in the oscillator by inserting a low-value non-inductive resistor in series with the crystal and measuring the RF voltage drop across the resistor. Solving the equation E(2)/R will give the drive level. A 10-ohm resistor generally will be adequate, although lower would be better. When measuring the drive level on fifth and seventh overtone crystals that have a choke coil across the crystal, insert the resistor in series with both the choke and the crystal.

If you get nothing else from this article, please remember that crystal oscillators are frequency generators, not power generators. To obtain more power, use the amplifier stages that are needed to get to the desired power level. You will end up with a much more stable, long-life oscillator.

Crystal manufacturers expend considerable effort to address the aspect of aging. The end user can take steps to avoid neutralizing this effort. Keeping the drive level at or below 1 mw is the first and easiest step. Second, refrain from doing anything that will damage the integrity of the holder seal. For example, do not solder to the cover of a solder-seal crystal.

Other components in the oscillator circuit can cause frequency changes over time that can be mistakenly attributed to crystal aging. Changes as subtle as the relieving of stresses in solder joints can cause small, but measurable changes in frequency.

Variable capacitors exhibit a phenomenon known as *creep*. This is when the capacitance changes from its set value over time.

Photo C. A simple fixture for measuring crystal frequency.

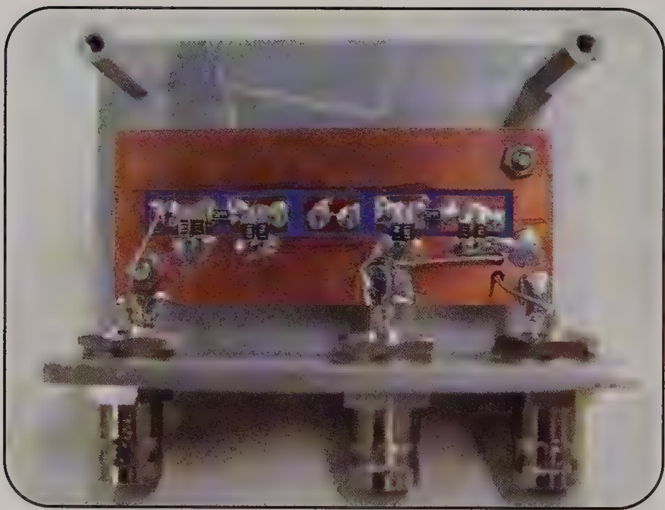

Photo D. A simple fixture for measuring crystal frequency with the cover removed.

Photo E. The 100HF, an HF instrument used for production testing of crystals.

Photo F. The 200VHF, a VHF instrument used for production testing of crystals.

Most variable capacitors exhibit some degree of creep. Piston capacitors and air-variable capacitors generally are less prone to creep. Some of the ceramic capacitors can be virtually unusable in that they seem to never stop changing. Remember that very small changes in capacitance can translate to unacceptable changes in oscillator frequency.

When measuring oscillator frequency, be aware that loading effects can cause significant changes. A small one- or two-turn loop on the end of a piece of coax often will be sufficient to drive a counter with minimal loading. If the oscillator drives amplifier or multiplier stages, make the frequency measurements as far down stream as practical. This will help to isolate the effects of measurement.

Speaking of counters, one can be deceived by all those digits. Many low-priced counters advertise accuracies of ±.001%. Just how much is that in real frequency? On 20 meters, it is ±140 Hz, which is not a problem. On 2 meters, the possible error is ±1400 Hz. Hmm, now that is a real difference, but more of a nuisance than a problem. On 3 cm the error is ±100 kHz (problem)! It's going to take a lot of tuning to make the schedule.

Suppose we bought a counter that has an accuracy of ±0.5 PPM. Would the extra expense be justified? On 20 meters we are now looking at ±7 Hz, so we really can't justify the added cost. On 2 meters we are looking at ±70 Hz, so maybe the added cost is justified—then again, maybe not. On 3 cm we now have an accuracy of ±5 kHz, which is still not great, but we have given ourselves at least a good chance of finding that weak signal, so the cost is easily justified. However, with the proliferation of GPS disciplined frequency standards, it is realistic to be able to get counters to run at an accuracy of better than parts in 10^{-9}. This translates to 10 Hz at 10 GHz.

Summary

The frequency of crystal oscillators is dependent upon many factors. We have discussed some of the considerations, such as temperature effects, drive level, and external components. ■

Note

1. The values given are representative only and should not be construed as values for a particular crystal. They are given only to demonstrate the magnitude of the parameter change with respect to overtone of operation.

Portable PREDICT Plus!

A Satellite Tracking, Pacsat Yakking, APRS Hacking, Linux Packing Mini Application Suite You Can Carry with You

KD2BD describes a stand-alone suite of satellite tracking and digital communication applications you can run just about anywhere from a pair of floppy disks.

By John A. Magliacane,* KD2BD

Maybe you run a Linux PC at home to track satellites, bounce APRS[1] packets off the International Space Station, or exchange e-mails and files via AMSAT's new Echo satellite. Maybe you would like to take that capability with you on Field Day or to club meetings where Linux[2]-based PCs are scarce. Maybe you run the DOS version of PREDICT and would like to tinker with it in its native Linux environment. Maybe Linux has caught your attention, but the process of choosing and installing a suitable distribution, and then having to configure all the amateur radio applications correctly, seems like an overwhelming task. Maybe you're having difficulty setting up your Linux box for satellite tracking and pacsat communication work, and you would like to take a peek at a properly configured system to see how everything fits together.

Maybe Portable PREDICT Plus! can help. Portable PREDICT Plus! is a tiny distribution of the Linux operating system that combines the AX.25 networking capabilities and multitasking nature of Linux together with the interoperability of many Linux-based amateur radio communication applications. It delivers them together in an elegant and effective communications package that is of particular interest to VHF and above spectrum users.

Portable PREDICT Plus! includes time-proven applications and utilities designed for pacsat communications, traditional packet radio communications, EME (Earth-Moon-Earth), APRS (Automatic Position Reporting System) beacon generation, and general satellite tracking. Best of all, it runs off a pair of innocuous 3.5-inch floppy disks and operates entirely in RAM. There's no need to fuss with your current PC setup. There's no need to format or partition your hard disk. In fact, you don't even need a functioning hard disk or a CD-ROM drive on your computer to install or run Portable PREDICT Plus! Its small footprint and meager requirements also make it a great "if all else fails" communications package in the event the unthinkable ever occurs and you really need something that works.

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Figure 1. PREDICT tracking the International Space Station. PREDICT displays Doppler-corrected uplink and downlink frequencies to aid in making voice contacts through a quickly moving satellite. AutoTracking through an AZ/EL rotator system is also provided.

How It All Started

The idea for creating Portable PREDICT Plus! was sparked early last year through an e-mail exchange between Central California AMSAT Area Coordinator Cliff Buttschardt, K7RR, and myself. Cliff's work at Cal Poly with students developing a CUBESAT picosatellite revealed a strong interest in running Linux-based PREDICT satellite-tracking and orbital-prediction software for CUBESAT communication. The requirement of installing Linux on the satellite-tracking PCs, however, introduced some complications that the parties involved wished to avoid.

Cliff and the folks at Cal Poly started looking at the CDROM-based Knoppix distribution of Linux for this application in the hopes it might easily be adopted for this use. Meanwhile, my thoughts turned more toward developing a smaller,

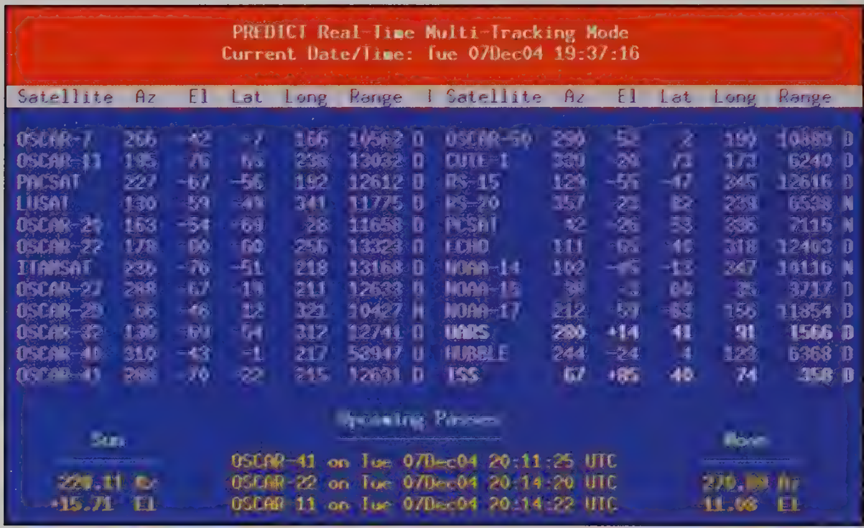

Figure 2. PREDICT in multi-tracking mode. Positions for 24 satellites plus the sun and moon are displayed in real-time. A list of upcoming satellite passes is displayed as well.

bootable floppy-disk version of PREDICT. This was due in part to the fact that I had already used floppy-based Linux distributions such as Trinux and Slackware's rescue disks with great success in the past, and I knew that PREDICT could very easily be made to run in such a bare-bones Linux environment.

Birth of a Distribution

Building a practical and functioning Linux system and distribution from scratch is a bit more involved than simply typing "SYS A:" and copying files to a floppy disk, as was the case in the days of MS-DOS. Fortunately, Linux is a very open environment with many knowledgeable users who are eager to share their knowledge. With several excellent "HOWTO" documents that describe the process of building Linux boot and root system disks available on the net, it wasn't long before a brand-new Linux computing environment was born. As progress was made, it was soon realized that enough free space was available on the newly created Linux distribution to include not only PREDICT, but many other satellite-related applications as well.

How It Works

Portable PREDICT Plus! operation starts with a boot disk containing a recent Linux kernel into which drivers for common PC hardware have been compiled. Support for 80386 and above (or compatible) CPUs, plug-and-play hardware, serial and parallel ports, CDROMs, ZIP and floppy disk drives, and (E)IDE hard disks have been included. Drivers for ext2, ext3, msdos, vfat, ntfs, udf, iso9660, and ramdisk file systems, as well as network drivers for the AX.25 and TCP/IP protocols, and serial drivers for multikiss and 6pack terminal node controllers (TNCs) are also included.

After a PC has been booted from a Portable PREDICT Plus! boot disk, the kernel is loaded into memory and its execution begins. After the kernel probes the PC's hardware and loads appropriate drivers, the user is prompted to exchange the boot disk for a Portable PREDICT Plus! root disk. The root disk contains a Linux file system containing nearly four megabytes of software that have been compressed to fit on a single 1.44 megabyte floppy disk. The root disk is uncompressed as it is read and is placed into a section of memory allocated by the kernel as a RAM disk. The RAM disk operates in much the same way as a hard disk, but has several advantages over the latter. First, being fully electronic, a RAM disk is unbelievably fast. Second, operating from a RAM disk avoids any chance of interference to software or operating systems already stored on the PC's hard disk.

After loading of the root disk is complete, users may "log into" the system with a username (and optional password), just like a traditional Linux system. First-time users run a "setup" utility to configure and personalize their Portable PREDICT Plus! environment. Information regarding their callsign, geographic location, TNC serial port connection, and baud rate are entered. An IP address that is used for internal networking is also selected at this time.

While the RAM disk is lightning fast and secure, its storage is only permanent as long as power remains supplied to the PC. Therefore, a "backup" utility is included with Portable PREDICT Plus! to save session contents and configuration information to a third "data" disk before the PC is powered down. The next time Portable PREDICT Plus! is run, the contents of the data disk are restored to the RAM disk using the "setup" utility, and everything is back to the way it was before the last session was ended.

In addition to providing a means for permanent data storage, the data disk also serves as an important medium for information exchange. The data disk allows

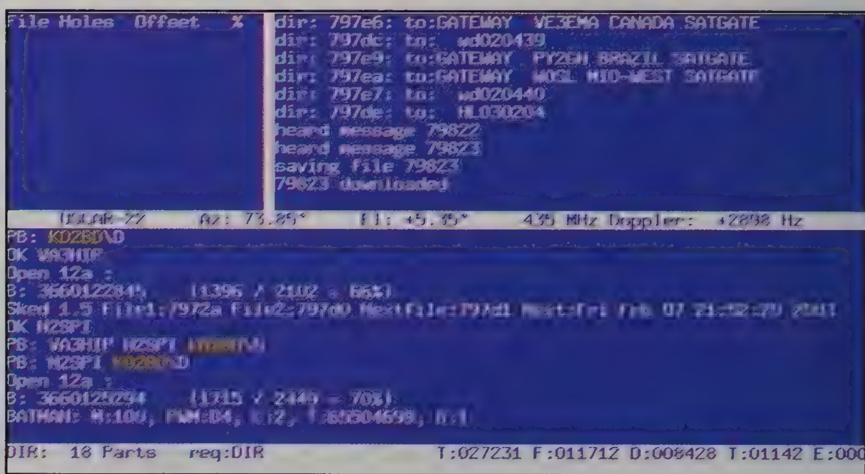

Figure 3. Intercommunication between applications: pb is shown communicating with the UoSAT-OSCAR-22 satellite just prior to LOS (loss of signal). Real-time tracking data in the center of the window is courtesy of PREDICT and its UDP network interface capabilities.

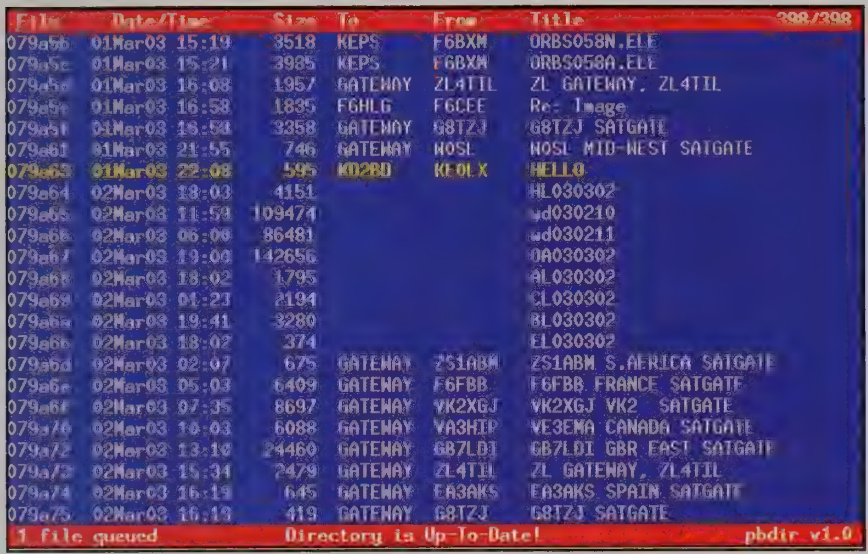

Figure 4. Cooperation between applications: "pbdir" is shown displaying satellite directory information. Files that have been queued for downloading are highlighted.

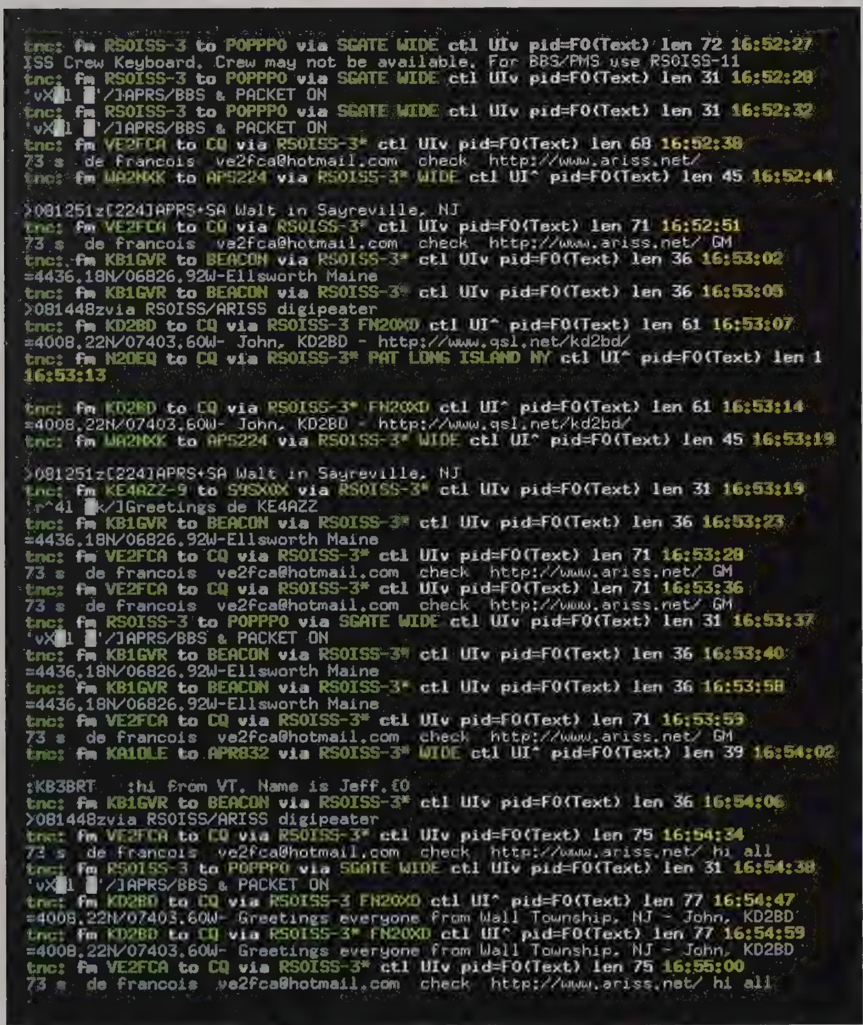

Figure 5. Packets received via the International Space Station by KD2BD using Portable PREDICT Plus! on December 8, 2004. A UTC timestamp is displayed in yellow. The packets originating from KD2BD were generated through Portable PREDICT Plus!

up-to-date Keplerian orbital elements used for satellite tracking and orbital prediction functions to be imported into a running Portable PREDICT Plus! environment. Conversely, files and directory information collected from a pacsat satellite during a Portable PREDICT Plus! session may be exported out of the operating environment using the same disk. The exported files can be used again in a future session as described earlier, or perhaps elsewhere in another environment, whether it be DOS, Windows®, or a traditional Linux installation.

The Suite is Neat (and very complete)

Portable PREDICT Plus! contains PB/PG, an FTL/0 protocol pacsat satellite communications suite by Bent Bagger, OZ6BL; PacsatTools, a collection of pacsat satellite communication utilities; "minicom," a popular terminal communications package; and MoonTracker, an application for predicting moon rise and tracking the position of the moon across the sky through an AZ/EL rotator system.

Also included are "must have" TNC and packet radio utilities such as "setserial," "kisson," "kissoff," "kissattach," "kissparms," "listen," "call," "mheard," and "beacon." Joe Dellinger's classic "morse" program is included as a replacement for PREDICT's English-speaking "vocalizer" utility, which couldn't be included because of size and soundcard driver requirement restrictions. Instead, added to Portable PREDICT Plus! is a replacement for the "vocalizer" that sends live azimuth and elevation satellite bearings to the user via the PC's speaker using Morse code. The Morse application is also available to the user for practicing CW skills while waiting for satellite passes.

Many classic Unix core utilities—such as colorized "ls," "vi," "ash" (a small bash-like shell that features command and filename completion and command history), "cal," "date," "ping," "ifconfig," "netstat," "route," "top," "zip," "gzip," and more (literally) are provided through a single, powerful, multi-call application known as "Busybox." All the associated dynamically linked libraries needed to produce a fully-functional Linux operating environment running under a 2.6.x kernel are included as well.

Operation

By now you're probably thinking that a familiarity with Linux and its AX.25

Callsign	Port	#I	#S	#U	First Heard	Last Heard
KB1GVR	tnc	0	0	15	Wed Dec 8 15:16:46	Wed Dec 8 16:56:22
VE2FCA	tnc	0	0	18	Wed Dec 8 15:14:50	Wed Dec 8 16:56:11
KD2BD	tnc	0	0	10	Wed Dec 8 15:14:14	Wed Dec 8 16:55:52
RS0ISS-3	tnc	14	17	44	Wed Dec 8 15:12:58	Wed Dec 8 16:55:40
KB3BRT	tnc	0	0	4	Wed Dec 8 16:52:26	Wed Dec 8 16:55:30
KA1OLE	tnc	0	0	2	Wed Dec 8 16:51:17	Wed Dec 8 16:54:02
WA2NXK	tnc	0	0	4	Wed Dec 8 16:51:28	Wed Dec 8 16:53:19
KE4AZZ-9	tnc	0	0	3	Wed Dec 8 15:13:17	Wed Dec 8 16:53:19
N2OEQ	tnc	0	0	2	Wed Dec 8 16:52:20	Wed Dec 8 16:53:13
VE3FFR	tnc	0	0	2	Wed Dec 8 15:15:43	Wed Dec 8 16:51:52
KX9D	tnc	0	0	14	Wed Dec 8 15:13:08	Wed Dec 8 16:51:19
W1SNE	tnc	0	0	2	Wed Dec 8 15:16:14	Wed Dec 8 16:51:18
KE4AZZ	tnc	0	0	1	Wed Dec 8 16:51:03	Wed Dec 8 16:51:03
RS0ISS-11	tnc	4	8	6	Wed Dec 8 15:14:53	Wed Dec 8 15:16:46
K4IPH-7	tnc	0	0	2	Wed Dec 8 15:15:26	Wed Dec 8 15:15:47
AG4ZQ	tnc	0	0	1	Wed Dec 8 15:14:25	Wed Dec 8 15:14:25
KG0YJ	tnc	0	0	2	Wed Dec 8 15:13:54	Wed Dec 8 15:14:15
KB0OFD-10	tnc	0	0	3	Wed Dec 8 15:13:04	Wed Dec 8 15:14:00
N0AN-6	tnc	0	0	1	Wed Dec 8 15:13:42	Wed Dec 8 15:13:42
N7OFW	tnc	0	0	1	Wed Dec 8 15:13:32	Wed Dec 8 15:13:32
VE3TZS	tnc	0	0	1	Wed Dec 8 15:12:56	Wed Dec 8 15:12:56

Figure 6. "mheard" log of stations copied over two consecutive passes of the ISS by Portable PREDICT Plus! The number of each packet frame type copied is also displayed.

utilities would be a good thing to have to run all the applications included in Portable PREDICT Plus! Familiarity and experience are always helpful, but nearly every application included in Portable PREDICT Plus! has been pre-configured at the factory. Full documentation on all applications has been included as well, so success, even among newcomers to Linux, often is quite good.

The applications selected for inclusion in Portable PREDICT Plus! inter-operate extremely well. For example, PREDICT can be run in "network server mode" to supply live satellite tracking data to other resident applications. Under Portable PREDICT Plus! it is possible to have pacsat satellite communications package "pb" poll PREDICT for live tracking data through its UDP network interface, thereby allowing "pb" to report this information as part of its regular on-screen display (figure 3).

In a similar manner, PREDICT and MoonTracker can also supply tracking information via a serial port to antenna rotator controllers employing the EasyComm-2 protocol. But all you have is a FODtrack interface to your rotator controller? No problem. A "fodtrack" utility is included which takes the tracking data that would normally be sent to an EasyComm-2 compatible controller, converts it into the format required by the FODtrack interface, and sends it through the parallel port to your interface.

A collection of PacsatTools is also included to perform pre- and post-pass processing of pacsat satellite data. Files downloaded by "pb" may be processed through "phs" to display and strip pacsat file header information from downloaded files. "phs" also "unzips" ZIP compressed files as needed without the requirement for manual user intervention. Pacsat directory information may be browsed, and file download requests may be made through "pbdir" (figure 4). Messages can be composed through "vi," compressed using "zip," and processed through "pfhadd" prior to being uploaded to a satellite through "pg." "dos2unix" and "unix2dos" text format conversion utilities are included as well, should the need for them ever arise.

Cooperation and Multitasking

The intercommunication and cooperation between small applications that work in concert to perform larger, more complex tasks under Portable PREDICT Plus! is really no different from the process that would normally take place in a larger Linux environment. This "division of labor" approach is the essence of the Unix (and Linux) computing philosophy, and was instrumental in successfully squeezing a lot of computing flexibility into a very small package.

How does all this sequential and concurrent computing take place on a PC with only a single monitor and keyboard combination and no windowing environment? Portable PREDICT Plus! supports a system of eight "virtual consoles." Each provides completely independent screen and keyboard combinations (consoles) for logging into the system, and running, and controlling applications. Virtual console number one is the console first displayed at startup. Switching between consoles is accomplished simply by holding the left Alt key on the keyboard while simultaneously pressing a function key (F1 through F8) that corresponds to the virtual console desired. It is through these virtual consoles that a user can simultaneously monitor the progress of a satellite pass in real-time, run predictions for other satellites, initiate file transfers with a pacsat satellite, view pacsat directory information, select files on the satellite for downloading, compose messages for uploading, monitor AX.25 channel activ-

KD2BD's Orbit Calendar For ISS

Date	Time	El	Az	Phase	Lat	Long	Range	Orbit	
Wed 08Dec04	15:12:37	[illegible]	293	236	45	99	2164	34571	*
Wed 08Dec04	15:13:43	[illegible]	302	239	47	94	1815	34571	*
Wed 08Dec04	15:14:48	7	315	242	49	88	1526	34571	*
Wed 08Dec04	15:15:53	10	333	245	50	82	1336	34571	*
Wed 08Dec04	15:16:58	11	354	248	51	76	1289	34571	*
Wed 08Dec04	15:18:02	[illegible]	14	251	52	69	1398	34571	*
Wed 08Dec04	15:19:07	[illegible]	30	254	52	63	1633	34571	*
Wed 08Dec04	15:20:12	[illegible]	41	1	52	56	1950	34572	*
Wed 08Dec04	15:20:53	0	46	3	51	52	2172	34572	*
Wed 08Dec04	16:49:07	0	314	250	51	96	2166	34572	*
Wed 08Dec04	16:50:12	3	323	253	52	89	1819	34572	*
Wed 08Dec04	16:51:17	7	336	256	52	83	1530	34572	*
Wed 08Dec04	16:52:22	10	354	3	51	76	1342	34573	*
Wed 08Dec04	16:53:27	11	15	6	51	70	1296	34573	*
Wed 08Dec04	16:54:32	9	35	9	50	64	1406	34573	*
Wed 08Dec04	16:55:37	5	50	12	48	58	1640	34573	*
Wed 08Dec04	16:56:42	2	61	15	46	52	1956	34573	*

More? [y/n] >>

Figure 7. A PREDICT orbit calendar for passes of the International Space Station.

ity, practice CW, and even select a track on a favorite audio CD.

Hardware Requirements

It doesn't take a modern, high-end PC to run Portable PREDICT Plus! A 100-MHz Pentium-based PC has more than enough muscle to perform all the operations described here simultaneously without ever breaking a sweat. For lower-end systems such as 80386s and 80486SXs, a math co-processor, while not required, is strongly recommended. Since four megabytes of RAM are allocated for use as a ramdisk and additional memory is needed for normal program execution, a minimum of eight megabytes of memory are recommended for Portable PREDICT Plus! 16 megabytes will all but guarantee successful operation.

A packet radio terminal node controller and associated radio equipment (obviously) are also required. The TNC need not be fancy. A simple TNC-2 or suitable clone that is capable of KISS-mode operation is all that is needed. Scripts are included in Portable PREDICT Plus! to easily bring the host TNC into and out of KISS mode. Other scripts modify the kernel's AX.25 parameters for half- or full-duplex operation as needed. A terminal emulator ("minicom") is also included for managing and configuring the TNC in standard (non-KISS) mode.

Building the Disk Sets

Portable PREDICT Plus! disk sets are packaged with electronic documentation and software required to write the root and boot disk images to blank floppies. Two packages are available—one for building the disk sets under an existing Linux environment and one for use under a DOS or Windows® environment. Each package is about 3 megabytes in size, so they can be downloaded quickly, even over a dial-up connection.

Links to these files, and the latest news on this project, are available on the PREDICT website.

Conclusion

Linux distributions currently number in the hundreds, and the quantity continues to grow. While most are designed to be installed permanently to a hard disk through a CD-ROM based installation procedure, a growing number of smaller, non-permanent, application-specific distributions are making their way onto the scene. Portable PREDICT Plus! is one such distribution.

What at first appeared to be a novel exercise and a simple challenge to create a miniature Linux environment has resulted in a flexible and practical stand-alone communication suite well worth the time and effort invested to develop it. Released to the Internet under the GNU General Public License, its use is open to all who seek it. New uses are found almost daily, from repairing Linux PCs at work, to configuring network routers and switches. In fact, it should come as little surprise that Portable PREDICT Plus! was even used to compose this little article. ■

Notes

1. APRS is a registered trademark of Bob Bruninga.
2. Linux is a registered trademark of Linus Torvalds.

Further Information

PREDICT Software: <http://www.qsl.net/kd2bd/predict.html>
The Echo Project Page: <http://www.amsat.org/amsat-new/echo/>
Amateur Radio Software for Linux: <http://radio.linux.org.au/>
PREDICT @ AMSAT.ORG: <http://www.amsat.org/amsat-new/tools/predict/>
Cal Poly Picosatellite Project: <http://polysat.calpoly.edu/index.html>
The Linux Bootdisk HOWTO: <http://www.tldp.org/HOWTO/Bootdisk-HOWTO/index.html>
APRS Beacon Creation: <http://web.usna.navy.mil/~bruninga/iss-aprs/issicons.html>

DFing a Lifesaving Transmitter

Hidden-transmitter hunting can be more than just a fun aspect of our hobby. It can have a serious side as well. Here N9SFX tells the story of when an Alzheimer's patient tracking device disappeared during a demonstration—and how hams saved the missing transmitter.

By Peter L. Ostapchuk,* N9SFX

I was amazed to see a foxhunter on the front page of the November 20, 2004 edition of the *Elkhart Truth.* On closer inspection, it turned out to be a picture of Captain Ron Biller of the Bristol, Indiana police department trying out a tracking device that is part of Project Lifesaver. I guess he really is a foxhunter, just not a ham, as far as I know.

The system was designed five years ago by the sheriff's department in Chesapeake, Virginia. It's a system that has been in use for decades in pursuits such as ham radio and wildlife tracking (see the May 1998 issue of *QST*). It consists of a 3-element Yagi antenna connected to a receiver that is worn on a neck strap. The tracking device is used to track persons such as Alzheimer's patients who might have wandered off. The patient wears a transmitter about the size of a wristwatch. It is worn on the wrist and transmits a short carrier about once a second and lasting about 50 milliseconds. The unit costs $263 and will transmit nonstop for a month on one battery. The battery costs $15. The transmitters operate on many different frequencies, from 215 MHz to 216 MHz. This allows searchers to distinguish between one patient and another. The local organization is called Triad. See the sidebar for more on Triad and Project Lifesaver.

The Monday after I saw Ron Biller's photo, I got a call from Jim Kehr, N9DUZ, about a missing transmitter from Project Lifesaver. I couldn't understand why they needed me, when I had just read about the tracking devices two days before. Jim told me to call Captain Brad Rogers of the Elkhart County Sheriff's Department; he also happens to be co-chair of Triad.

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The author (left) and Ritch Williams, KA9DVL, try to locate the transmitter in the water using a submersible probe attached to a 10-foot pole.

Captain Rogers told me about a demonstration that had gone wrong. Triad had put on a training exercise on November 17–19. Several of the wristband transmitters had been deployed, and Triad members were able to go looking for them with the aid of the aforementioned tracking devices. All but one of the transmitters was found. One of them had become submerged in a lagoon on the edge of the Elkhart River. The water was only one foot deep, but the silt under the water extended for what seemed like forever. Hip waders were tried before the depth of the silt was discovered. A boat with a metal detector was tried, but the transmitter was never found.

The transmitter with its o-ring seal was still transmitting, but Triad had no way to direction find the unit under water. The best they could do was find a general location in the river where the transmitter was submerged. I was amazed to hear that a signal was able to propagate through the water well enough to be heard above water.

The transmitter was operating on 215.02 MHz, but my Alinco DR235 would only go down to 216 MHz. My Kenwood TM-742 would go down to 215 MHz. I also have a Kenwood TH-F6 triband HT that receives from DC to daylight. I had built an 8-element Yagi for the 220-MHz band a couple of years earlier and it was still sitting around. I also had some of my homemade RF attenuators nearby (see October 1999 *CQ VHF*).

I loaded up my van and headed off to Goshen, hoping that maybe they had not done their foxhunting correctly. How-

The successful DFers return with the fox in hand.

ever, they were right; the transmitter was in the drink. They had not told me where the transmitter was located, but I listened to the 742 mobile on the way to Goshen and started picking up the transmissions as I neared the downtown area. In a few minutes I knew that it was located just behind the County/City Building. The 220-MHz beam with the attenuator and Kenwood TH-F6 worked well at 215 MHz, but again it only told me that the transmitter was in the middle of the lagoon. It was a short walk to meet with Warren Allender, director of Emergency Management in the County/City Building. He came out to the lagoon and confirmed that I had found the right location.

On Tuesday, November 23 I came up with an idea for a submersible probe. It consisted of a piece of RG-58 A/U with one inch of the center conductor exposed and water proofed. I strapped it to a 10-foot long pole and put a BNC connector on it. I asked Wayne Zehner, K9WZ; Dave Evans, AA9DG; Alan Rutz, WA9GKA; and Larry Wheeler, W9QR, for their blessings on the probe and got them. These guys know more than most hams could ever dream of knowing about RF!

I took the probe to the lagoon that afternoon and tried it as best I could without a boat to see if the idea would work. I walked up and down the shoreline and could see the signal go slightly up and down with the changing distance to the transmitter. Even with the 10-foot pole, the probe was still about 30 feet from the transmitter at its closest.

Wednesday was cold, windy, and rainy. That's not foxhunting weather. Rather, that's antenna installation weather. Thursday was Thanksgiving and everyone was with their families. I was anxious to get the job done so I could determine if the probe would work as expected. The other issue was the battery. I knew that the transmitter had been on for at least eight days as of Friday, but I didn't know how many training exercises it had been used for prior to this one. Once a battery is dead, the foxhunt is effectively over.

On Friday, Ritch Williams, KA9DVL, brought his inflatable boat to Goshen. Larry Rodino, KC9DMG, and Dave Evans, AA9DG, were on the shore as camera crew/rescue team. Ritch and I put out into the lagoon and headed toward the suspected spot. I switched the TH-F6 to CW and could listen to the tone caused by the short carrier coming from the transmitter. I slid the probe back and forth under water, out ahead of the boat, while listening to the signal on the HT. As we got closer to the transmitter, I kept adding attenuation. By the time we were on top of the transmitter, I had switched in all 95 dB of attenuation and still had a healthy signal. This is amazing, as the signal from the transmitter is only 5 microwatts. I tried listening to the third harmonic, but could not hear a thing there. The transmissions were too short for the S-meter to respond. We were DFing by field strength as indicated by the sound coming from the HT.

Triad and Project Lifesaver

By Captain Brad Rogers
Elkhart County Sheriff's Department

Triad is a nationally recognized organization, with each local Triad developed and controlled at a local level, involving law enforcement, social services agencies, and senior citizens. The scope of Triad is aimed at reducing the victimization of senior citizens. This involves not only criminal victimization, but other ways in which seniors can become victims, such as in emergency disasters and other senior living issues, including Alzheimer's.

Elkhart County (Indiana) Triad, in existence since 1999, recently decided to join Project Lifesaver to provide this community service. Project Lifesaver is an active system that relies on proven and reliable, state-of-the-art radio technology and a specially trained search-and-rescue team. People who are clients of Project Lifesaver wear a wristband that contains a unique frequency that emits a tracking signal 24 hours a day. When caregivers notify the local Project Lifesaver agency that a client is missing, a search-and-rescue team responds to the point where the person was last seen and starts searching with this tracking system.

Search-and-rescue teams are composed of Triad members, some of whom are police officers, while others are volunteer citizens who want to make a difference. Search times have been reduced from hours and days to minutes. In fact, Project Lifesaver has over 1000 documented saves, a 100% success rate, and a national average find time of 22 minutes.

Project Lifesaver is not just for persons with Alzheimer's. In fact, children with autism and other persons with mental disorders who are prone to wander can also be placed in this program. In addition, Project Lifesaver clients who travel to other areas in the country that participate in Project Lifesaver can be tracked by trained personnel if they wander away.

Contact your local Triad or Project Lifesaver International for more information. As a law enforcement officer who knows the frustration of trying to find a missing person, I encourage every local jurisdiction to participate in Project Lifesaver. For more information, contact me via e-mail at <brogers@elkhartcountysheriff.com> or visit <www.projectlifesaver.org>.

After 10 minutes we were right on top of the transmitter. The 20-foot diameter circle that was indicated from DFing from shore had shrunk to a 1-foot diameter circle. The problem was that the transmitter was only an inch and a quarter in diameter and had been covered by silt. I was hoping to reach into the water and grab the device, but the sides of the boat were a little bit high and the extra 1-foot depth of water made me resort to plan B. I lowered a large magnet into the area and swished it around for a couple of minutes. The battery of the transmitter was attracted to the magnet and the rest is history.

The whole process in the water lasted about 20 minutes. No one knows for sure how the transmitter wound up in the river, but I did notice a lot of ducks in the area. The transmitter had been sitting on a tree stump a few feet from the edge of the water. It would not be much of a stretch to think that a duck could have picked up the beige-color device and carried it out into the water. Insert your own theory here.

I did a little testing with the transmitter after I got back home. There I determined that the second harmonic would have been the harmonic of choice. The second harmonic is at 430 MHz and in the ham band. I tried my homemade 10-element 440-MHz beam and was able to DF the transmitter out to 100 yards. The fundamental is easily DFed at one mile in open country when using my 8-element 220-MHz beam. I was able to pick up the third harmonic by bringing the transmitter to within a couple of inches of the TH-F6 with the rubber duck re-installed. The problem with the third harmonic could very well be the sensitivity of the TH-F6 at the third harmonic, 645.06 MHz. I listened to the TV stations in the area by tuning to the FM audio frequency. Channel 22 with an FM audio frequency of 523.750 MHz came booming in, but those frequencies around 600 MHz were barely discernible. I guess this would be called a poor-man's service monitor.

I tried shortening the exposed center conductor from 1 inch to 3/16 inch. I tried the new design in the river, but it did not work as well as the 1-inch version. My hunch is that the probe should be a quarter wavelength of the center conductor wound into a coil not unlike a rubber-duck antenna. The only problem with the first two designs was that it was difficult to zero in right on the transmitter. The shorter version gave an increasing signal while closing in on the transmitter until the probe was about 2 feet away from the transmitter. Then the signal started to decrease until the probe was in contact with the transmitter with almost no signal left. Obviously, this problem is not significant when looking for a patient with a wristband attached. It's only significant for those who have to find a very small transmitter under water. I'm here to tell you that it can happen.

On December 8, 2004 there was a Triad meeting in Goshen and the fox-hunters were invited to attend. Captain Rogers presented us with certificates of appreciation. After the meeting we were able to see the equipment used by Project Lifesaver.

If Project Lifesaver has made its way to your area, you might want to see if the group can use your help. If it has not, you might want to see if your area might consider Project Lifesaver. There are a lot of ways that amateur radio can be of service to the community, and Project Lifesaver is just one of them. I'm fortunate to have been able to locate transmitters for the PHM school system, Goshen fire department, Triad, the Elkhart and South Bend airports, and the Civil Air Patrol.

It appears that the Project Lifesaver equipment could be made compatible with underwater DFing. All that would be needed is a submersible probe similar to the one I used in the river. It would simply be substituted for the 3-element Yagi antenna that is normally used when searching for the transmitters on land. It would be a mistake to assume that a patient will never walk off and end up in the water. It would also be a mistake to think that divers only have to dive in the summer in clear water. By the time the patient is found under water, it's probably too late. On the other hand, the divers who have to go down in frigid water with zero visibility to search for the patient would rather be able to follow a coax down to the transmitter or have a probe that they could take down with them to tell them if they are moving in the right direction. This is obviously my personal opinion, but the more tricks you have up your sleeve, the more service you can provide.

The underwater probe is like the fire extinguisher that you hope you never have to use. If you have a 220-MHz beam on a tower with a rotor, you could be a real asset to those who have to locate a missing patient who has had a head start on the folks from Triad. The Amateur Radio Service . . . It's a hobby, and it's also a *service.* ■

By Joe Moell,* KØOV

Radio Direction Finding for Fun and Public Service
Win Foxhunting Prizes, Mobile or on Foot

"I love ARDF! It's so interesting!" Those aren't my words, but they could have been. Matthew Robbins, AA9YH, wrote them upon his return from the 2004 World Championships of Amateur Radio Direction Finding (ARDF) last September. ARDF is an all-on-foot form of hidden transmitter hunting that is done around the world. It is also called foxtailing and radio-orienteering.

This was Matthew's first ARDF World Championships (photo 1). In fact, his journey to the Czech Republic was his first-ever trip outside the USA. He earned his position on ARDF Team USA at the 2003 USA ARDF Championships near Cincinnati.[1]

AA9YH and the other competitors on our team didn't do as well as they had hoped, but their performances were remarkable when you consider that they were up against the planet's best radio foxhunters on probably the most difficult ARDF courses ever. The championships attracted 327 competitors from 28 countries to Brno, a town about 110 miles southeast of Prague. They were divided into five age categories for males and four age categories for females, in accordance with rules of the International Amateur Radio Union (IARU).

Each country was permitted to have up to three persons per category on its team. Medals were awarded to best individuals and best national teams in each age/gender division and on each band. Men under age 40 and women under 35 competed on 80 meters Thursday, September 9 while the rest did their 2-meter hunt. The reverse occurred on the following Saturday.

The 2-meter course facing 2004 World Championship contestants encompassed about 4800 acres of forest, with occasional thickets, slopes, and cliffs. The gold-medal winner in the 2-meter prime age category for men, a Czech, found all five "fox" transmitters and finished in less than 78 minutes (home court advantage?). By comparison, nearly 9 percent of the starting competitors didn't get back within the 2½-hour time limit or found no foxes at all.

Photo 1. Matthew Robbins, AA9YH, nears the finish line of the 2004 ARDF World Championships in the Czech Republic with his 2-meter gear and tattered map. (Photo by Richard Thompson, WA6NOL)

Photo 2. Atop the mid-town dirt pile, Mike Pendley, K5ATM, gets a bearing on an Albuquerque hidden transmitter. He is a co-chair of the 2005 USA ARDF Championships in "Duke City" this August. (Photo by Joe Moell, KØOV)

Two Team USA members had top-ten individual finishes in their categories. Nadia Scharlau of Cary, North Carolina placed sixth out of 22 on 2 meters. Bob Cooley, KF6VSE, age 62, of Pleasanton, California placed ninth out of 34 on his 2-meter run.

Jerry Boyd, WB8WFK, of Albuquerque, New Mexico, age 47, has over a decade of 2-meter transmitter hunting experience, but the myriad of signal reflections nearly got the best of him. Having found fewer transmitters than he wanted and nearing the finish with time running out, he lost his footing and slid down a slope and off a cliff. A tree broke his fall, but he landed on his back after falling through it. Fortunately, he was not seriously injured and was able to run on to the finish line.

This was the USA's fourth trip to the biennial World Championships. Our team members ranged in age from 19 to 62 and came from nine states. Team Captain was 62-year-old Harley Leach, KI7XF, of Bozeman, Montana. Also in the 21-member USA delegation were Dale Hunt,

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Photo 3. Frank Morton, AC4MK, tries transmitter hunting for the first time at the 2003 Tampa Bay Hamfest. (Photo by KØOV)

WB6BYU, of Portland, Oregon and Marvin Johnston, KE6HTS, of Santa Barbara, California. They represented USA and IARU Region 2 (North and South America) on the International Jury overseeing the competitions. Each was assigned to be a Course Marshall at one of the radio foxes out on the courses.

European and former Soviet countries have been holding ARDF events for over 30 years, so it is no surprise that they dominated in the final standings. Nine of these nations garnered all of the individual and team awards. I watched the medal ceremony in streaming video on the internet and heard nothing but East European national anthems.

The total medal count was led by the Czech Republic, Russia, and the Ukraine with 34, 28, and 26, respectively. USA, Australia, and Great Britain were among the 19 nations that won no medals. Nevertheless, the teams of these three English-heritage countries enjoyed a friendly rivalry as they shared living quarters in the same corridor of the host facility.

There is more about ARDF Team USA 2004 at my "Homing In" website,[2] along with links to complete results on the Czech ARDF site and to pages of photos by team members.

You Could Win in '05

No matter what your age, if you can run or walk for 5 kilometers, then you can succeed in ARDF. The sport is growing quickly in the USA, and our national championship competitions are open to anyone of any age. This summer fox-hunters from around the USA and elsewhere in the world will gather in Albuquerque for the Fifth USA ARDF Championships. If there is sufficient participation from neighboring countries, it will also be designated as the Third IARU Region 2 ARDF Championships.

The Albuquerque activities will take place from August 1 through August 6. Besides separate on-foot direction-finding competitions on the 2-meter and 80-meter bands (August 3 and 5, respectively), there will be opening ceremonies, practice/training sessions, a sightseeing day, and a closing banquet with award presentations. The event center will be on the campus of the University of New Mexico (UNM), where competitors will be housed. Bus transportation to the competition sites will be provided.

Besides being open to all stateside radio-orienteers, the sponsoring Albuquerque Amateur Radio Club (AARC) welcomes visiting competitors from anywhere in the world. The field will be divided into the IARU-standard age/gender categories, with medals for top finishers in each category. Winners who are citizens or residents of the USA will be considered for positions on ARDF Team USA to the 2006 World Championships in Bulgaria.

Co-chairs of the organizing committee are Jerry Boyd, WB8WFK (yes, it's the same Jerry who fell through a tree in the Czech Republic!), and Mike Pendley, K5ATM. Other team leaders are Scott Stevenson, KC5VVB, and Jack Stump, KD5OEO. AARC hosted the First USA ARDF Championships in 2001 and hopes to provide even more fun for all this time.

Because many conferences and other events will take place at UNM this summer, the organizers are conducting an informal survey to get a preliminary head-count. This will ensure that sufficient housing and other resources are reserved and available. If you think you will be able to attend, please e-mail WB8WFK (wb8wfk@att.net) now to indicate your interest on a no-obligation basis.

AARC's official website for the 2005 USA championships[3] is now online with more details about housing, rules, frequencies, and the climate of central New Mexico. You can also download registration forms and find out how you or your company can become an event sponsor.

Photo 4. Tim Van Nes, N9EL (right), receives his award from Chris Schwab, N4BSA, for winning the 2004 Tampa Bay Hamfest foxhunt. (Photo by John Munsey, KB3GK)

RDF on the Road

As regular "Homing In" readers know, there are two very different ways that fox-hunters compete among themselves. In

Photo 5. Newcomer Jeffrey Fontaine, WD4USA, is intrigued by a homebrew active RF attenuator at the 2004 Tampa Bay Hamfest foxhunting forum. Later he borrowed some RDF gear and took second place in the hunt. (Photo by KB3GK)

addition to all-on-foot events such as the ones above, challenging mobile "T-hunts" take place around the country all year long. Besides being a center of excellence in ARDF, Albuquerque is also a hotbed of mobile T-hunting activity.

Twice a month hams gather at a dirt pile near the "Big I" junction of Interstates 25 and 40. They stand on top and strain their ears to hear a 2-meter signal from a fellow ham somewhere on the AAA map of the city and vicinity (photo 2). As often as not, the signal they hear is reflecting from the Sandias or other mountains nearby, so the hunt can become a real challenge.

Mobile hunters don't hold national and international championships like radio-orienteers do, but they like to take advantage of regional ham get-togethers to challenge one another. More and more hamfests and ARRL conventions are including hunts of both types, often with a substantial prize package. The annual Tampa Bay Hamfest[4] has just ended as I write this, and for the second year the organizers have challenged the radio-direction-finding fans of Florida.

My wife April, WA6OPS, and I were privileged to be speakers at the 2003 Tampa Bay Hamfest and to observe its first foxhunts, one for mobiles and another on foot on the convention grounds at the Manatee Convention Center in Palmetto. The locals were new to the sport back then and got a lot of exercise as they learned how to use their new RDF gear (photo 3). Most needed some clues to get them close enough to spot the mini-transmitters in the trees and bushes, but during the post-convention get-together at Roaring 20's Pizza, they all proclaimed that they had a good time.

Since then, they have greatly improved their gear and their skills. John Munsey, KB3GK, and Bill Thomas, KE4HIX, from Daytona handily won both hunts in 2003, so organizer Chris Schwab, N4BSA, asked them to conduct a forum and organize the hunt in 2004. John and Bill put on a show-and-tell of simple beams, RF attenuators, and mini-transmitters. Then they challenged attendees to find their five foxes, which were concealed outside the building on the grounds.

"Our foxes used the familiar 'MOx' tones and were timed to have ten seconds of dead air between their sequential transmissions," John wrote. "This was so that neophyte hunters would realize that a changeover was taking place. We planned #2 and #4 to be difficult to find, and #1, #2, #3 to be for the newbies."

In less than a half hour, Tim Van Nes, N9EL (photo 4), found all five transmitters to win first prize. He was 14 minutes ahead of second-place Jeffrey Fontaine, WD4USA (photo 5). "We started them from inside the building at one minute intervals," KB3GK explained. "Bill hid the transmitters such that each hunter would start in the opposite direction from the previous hunter. This staggered starting, plus starting from inside the lobby prevented them from following each other."

For years RDF contesting has been an important part of ARRL Southwestern Division conventions (Hamcons) when they take place in southern California. At Hamcon 2003, the Fullerton Radio Club provided opportunities for the mostly expert attendees to win prizes by hunting both mobile and on foot. The fun got under way Friday evening when cars, vans, and SUVs full of beams, quads, and Dopplers gathered in a parking lot a couple of miles from convention headquarters at the World Trade Center in Long Beach.

"No clues!" is the mantra of most southern California T-hunters, so the 16 participants didn't get any. They were merely told that some transmitters would come on 146.565 MHz at 7:30 PM. Their mission was to find as many as possible and return by 10:15. Each driver was

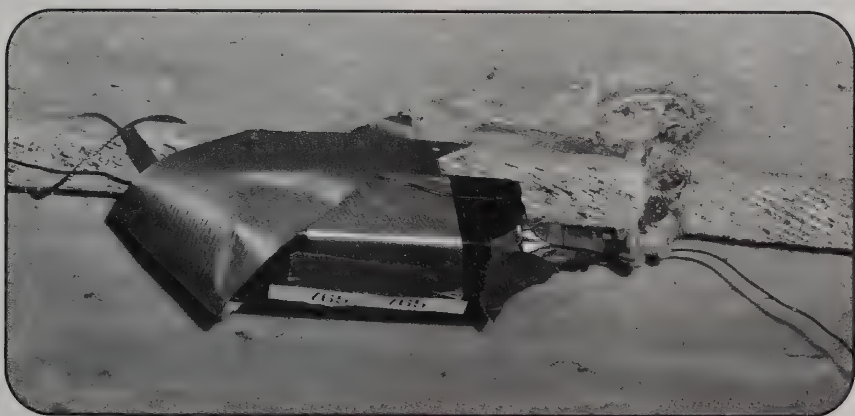

Photo 6. One of the 16 Hamcon 2003 ROCA transmitters was in the ceiling of an old Fort MacArthur tunnel. That made its signal highly directional. (Photo by KØOV)

given a card and told to mark it with the unique punch at each fox. Scoring was first by the number of Ts found and second by elapsed mileage, the lower the better. Hunters arriving back at the starting point after 10:15 had one T deducted from their score, and those arriving after 10:30 were penalized two Ts.

RDF on this hunt was difficult because the starting point was down by the ocean instead of on a hilltop, making signals weaker and bearings less reliable. Three of the four transmitters were very close to freeways, where reflections from moving vehicles caused bearings to flutter. Fox powers ranged from 1 watt and a whip on the one 7 air miles away to 40 watts and a beam on the one 29 miles away. That made their signal strengths at the start point about the same.

Some hunters claimed that it wasn't possible to get through Friday night traffic to all Ts and back in time. However, exactly one week before, I did just that. (Did I mention that I was hider for this hunt, with help from Mike Obermeier, K6SNE, and David Curlee, KE6IPY?) I test-drove the course in the most likely order, paused appropriate amounts of time for on-foot sniffing at each T, and got back with 94 miles on the trip odometer and about 15 minutes to spare.

The best strategy was to try to find the foxes in order from closest to most distant, while making sure there was enough time to get back by 10:15. That's what all the prize-winning teams did, even though none of them found all four. First place was taken by the team of Deryl Crawford, N6AIN, and J. Scott Bovitz, N6MI, who found three of the Ts in 93.8 miles.

Photo 7. Travis Wood, AE6GA, had the most unusual RDF setup at the Hamcon ROCA. The circular-element quad on top was for close-in hunting on fox harmonic frequencies. (Photo by KØOV)

A Rockin' ROCA

After the last Hamcon prize drawing on Sunday, 22 radiosports fans of all ages headed for the on-foot event. Pedestrian foxhunting is much newer on the southern California scene, but it has already surpassed mobile hunting here, when gauged by the number of participants on a typical hunt.

This hunt didn't use the IARU's international rules, which are more suited for hunters with the best fitness and for events in very large wooded parks. In urban areas it's better to have more transmitters, with varying levels of difficulty. That spreads out everyone and gives persons of all physical and skill levels a challenge and an opportunity for success.

The name often given to this type of urban multiple-fox hunt is ROCA, which stands for Radio-Orienteering in a Compact Area. The best places for ROCAs are not manicured parks with nothing but an expanse of perfectly mowed grass, a few trees, and no brush. It's far better to have some hills, dirt, bushes, outbuildings, trash piles, and so forth to provide good spots for concealing the transmitters.

The 130 acres of Angel's Gate Park in San Pedro are ideal for ROCAs. The north end has a big bunker pit, tunnels, buildings, and other fortifications left over from the site's days as Fort MacArthur. There are endless places to hide transmitters there (photo 6). In the middle of the park are Marine Mammal and Bird Rehabilitation Centers, plus the Fort MacArthur Military Museum. This part of the fort has been nicely restored and is open to the public on weekends, with self-guided and docent-guided tours.

I had hoped to put out 20 two-meter

Photo 8. Roger Denny, WB6ARK, checks closely to see if the toy cordless phone atop my van really is a fox transmitter, and which one of 16 it might be. (Photo by KØOV)

transmitters Sunday morning before everyone arrived. I ran out of time after 16, which proved to be plenty. One micro-T was cleverly camouflaged inside a toy cordless phone. I intended to place it on a shelf in the museum store, but one museum volunteer didn't show up, so the store wasn't open.

For fairness and to split the prizes, hunters were divided into four categories. All two- and three-person teams were in one category, while the other three categories were for individuals, by age range. Each team was allowed only one RDF set to prevent working independently for an unfair advantage. Everyone received a list of all the foxes by frequency, with clues as to the type of transmission to expect from each one (tones, voice, Morse, and so forth). Each hidden transmitter had a small sticker on it or on its antenna with a unique three-digit number. Hunters were instructed to put that number next to that fox on their hunt list to prove that they found it.

Some participants had just come from a convention homebrewing workshop presented by Marvin Johnston, KE6HTS, where they built their own tape-measure Yagis and offset attenuators. Others brought their own unique RDF equipment (photo 7). After the countdown, they took off to find as many foxes as they could within the 90-minute time limit.

Several hunters were immediately obsessed with a very strong signal a few feet from the start. It seemed to be coming from my van. They climbed all over it for a while. When one hunter asked if he could open the door, I suddenly realized why all the interest and intensity. Oops! The toy cordless phone that I couldn't put inside the still-closed store was on the back seat of the van, transmitting away. Even though I immediately got this phone-T out and put it on top of the van, it wasn't a "gimmie" to the hunters. Only two correctly identified it on their score sheets. Six others mistook it for another transmitter on the sheet that was 10 kHz higher in frequency (photo 8).

Best overall score was posted by Jay Hennigan, WB6RDV, of Santa Barbara, who found and correctly identified nine foxes to win the Senior age category. He is a long-time mobile T-hunter who recently took up on-foot hunting. His training helped him win gold medals in the males-over-50 age category at the last two USA ARDF Championships and a spot on ARDF Team USA 2004.

Winner of the Junior category and second-best overall with eight foxes was Jay Thompson, W6JAY, Amateur Radio Newsline's Young Ham of the Year for 2003 and co-winner of the ARRL Hiram Percy Maxim Memorial Award in 2004. W6JAY was also a national ARDF medal-winner in 2003 and 2004 as well as a Team USA member.

In the Prime Age category, the winner was Bob Dengler, NO6B, with six foxes credited. Best in the team category, with three foxes, were 12-year-old Steven Martinet and Phil Goodman, AE6DI. All category winners received gift certificates from a ham radio store. In addition, each competitor received one prize ticket for each fox that he or she found. Tickets went into a drum for chances to win from a table full of goodies.

In Closing . . .

For more details and photos of the Hamcon 2003 foxhunts, visit my "Homing In" website. If you are planning a hamfest or convention in your area, I hope you will include at least one transmitter hunt. It's a sure-fire way to inject more fun and excitement into the festivities.

As always, I welcome your foxhunting stories and photos for future columns. Please send them directly to me at the e-mail or postal address on the first page of this column.

73, Joe, KØOV

Notes

1. Moell, "Homing In: Championship Foxhunters Gather in the Buckeye State," *CQ VHF,* Winter 2004. This article also explains the basic rules of international ARDF competitions.
2. <www.homingin.com>
3. <www.ardf.us>
4. <www.fgcarc.org>

Receiver Dynamic Range—Part 2

Reprinted from *DUBUS Magazine,* in the second part of this two-part article SM5BSZ concludes his discussion of how to correctly measure receiver dynamic range.

By Leif Åsbrink,* SM5BSZ

In part one of this article we covered one-, two-, and three-signal dynamic range and the practical measurement of noise floor, as well as crystal notch filters. In part two, we cover the practical details of DR_2 and DR_3 measurements, and conclude with a discussion of how much DR we really need.

Practical Details of DR_2 Measurements

For a conventional receiver, the level of the weak signal makes no difference as long as the dynamic range of the IF and audio sections of the receiver under test is adequate. It makes no difference at all if the AGC is enabled or not, if the spectrum analyzer at the loudspeaker output is being used to simultaneously monitor the desired weak signal and the noise floor.

To check the dynamic range of the IF and audio sections, increase the level of the desired signal and monitor S/N. At some point, S/N will no longer increase in proportion to the input level. This is the level where IF or audio noise is no longer small compared with the noise floor at the antenna input, which has been reduced by AGC action, or it is the level where the signal does not increase anymore because of clipping. If the receiver under test has a dual-loop AGC, the level where an RF attenuator is inserted will be clearly visible in the plot of S/N versus input power. DR_2 measurements have to be made with the weak signal well below this level.

The way the two signal generators are combined is very uncritical for DR_2. The power level needed for the strong signal is below 0 dBm, and the weak signal may be somewhere around –130 dBm. A simple resistive network will be fine; connect the strong generator through a 5-ohm resistor, and add the weak signal through a 500-ohm resistor. A directional coupler or even a T-connector followed by a 6-dB pad to restore 50 ohms impedance will be fine.

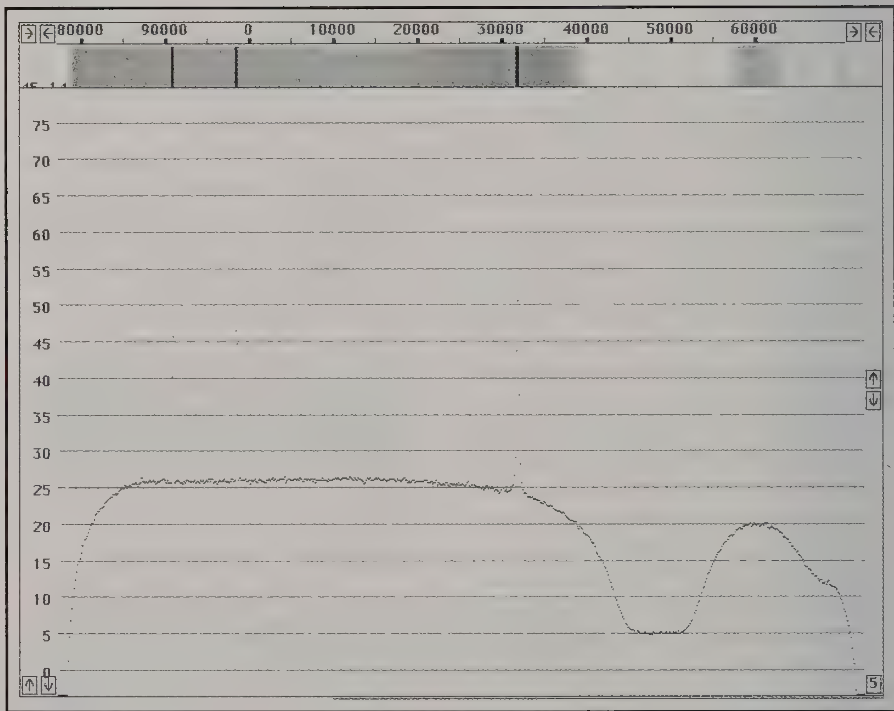

Figure 13. The Linrad spectrum of an HP8657A signal generator at 80- to 160-kHz offset. A practical illustration of the usefulness of a crystal notch filter for DR_2 measurements.

For the measurement, just select a frequency offset and adjust the strong signal for a 3 dB loss of S/N. DR_2 is given by equation (3), where PGEN is the level of the strong signal at the antenna connector of the test object. If the signal generator is calibrated, one only has to subtract the loss because of the cables and the signal-combining network. If the generator is not calibrated (it could be a homemade low-noise crystal oscillator), it is still possible to determine the power level from the noise figure as described in conjunction with figure 3, although one would then need calibrated attenuators to bring the power down for the saturation level to be somewhere around –130 dBm. Signal leakage is the critical point here.

To give an idea of the significance of using a notch filter, figure 13 shows the screen of Linrad with the spectrum from 144.08 to 144.170 MHz when an HP8657A generator set to 144.0 MHz is connected through the notch filter. The data book says that phase noise should be

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Reprinted from DUBUS Magazine, *4/2003 [12], [13] <http://antennspecialisten.se/~sm5bsz/index.htm>*

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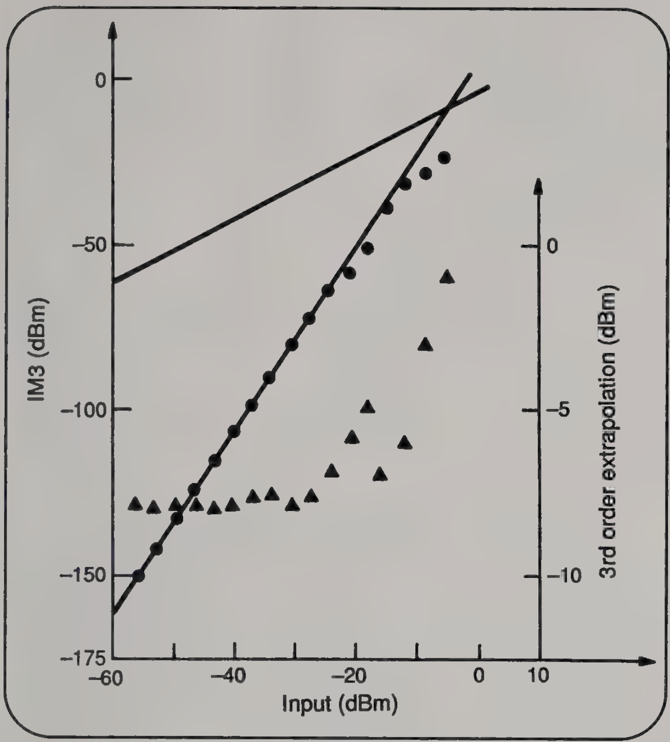

Figure 14. Measured levels of third-order intermodulation (circles) for an IC-706MKIIG with RF amplifier off and with AGC enabled. The result of a third-order extrapolation (triangles) gives the correct result (IP3 = –8 dBm) up to IM3 levels that are about 40 dB below the main signals.

below –136 dBc/Hz at a frequency separation of 20 kHz. The spectrum shown here shows that the sideband noise is –140 dBc/Hz at a frequency separation of 100 kHz. State-of-the-art commercial amateur transceivers are a little better than this. For example, the TM255E tested at the Scandinavian VHF meeting in Gavelstad had a DR_2 of 144.5 dB at 100 kHz (http://antennspecialisten.se/ ~sm5bsz/dynrange/gavelstad/gav.htm).

Practical Details of DR_3 Measurements

Unlike the DR_2 measurements, which really do not have any difficulties associated with them, DR_3 measurements have all sorts of problems. It is very easy to come up with incorrect results, particularly if the measurements are made at low levels of the third-order intermodulation products. On the other hand, measurements well above the noise floor may easily become incorrect if the S-meter or an RMS voltmeter at the loudspeaker output is used.

By measuring DR_3 with three signal generators as suggested here, it is possible to measure intermodulation correctly at high signal levels (but once again, if the unit under test has incorporated a dual-loop AGC, results will become incorrect at levels where RF gain is being reduced).

Problems with intermodulation measurement accuracy lie in the behavior of the test receiver with strong intermodulating signals. One cannot trust the intermodulation to obey the third-order law at high signal levels. For the more realistic situation with weak intermodulation products—below S6 or so, which we typically would notice when actually using the radio—the problems lie in intermodulation between the signal sources. These problems generally add some extra signal at the frequency where the third-order intermodulation is expected. Typically, one therefore will get results that underestimate the true performance of the tested unit, but the intermodulation signal could be in antiphase, and then the error may go in the opposite direction.

Once a good source of two equally strong signals has been arranged (see more about that below), the rest of the DR_3 measurement is easy. Use the block diagram of figure 2, and replace the noise generator with the two-signal source. Set the weak-signal generator (the one injected through the directional coupler) to a frequency close to the frequency where third-order intermodulation is expected. Set the two high-level generators for equal levels, and then set the weak signal to have the same level as the intermodulation product as seen on the spectrum analyzer. It does not matter if AGC is on or off; one will easily see when the signals have the same amplitude. It does not even matter if AF stages become saturated. Even IF stages may be saturated, provided that the two interfering signals are outside the IF passband. When intermodulation is measured this way, the third-order law is confirmed over a much larger range of input signal levels than one typically observes with other methods.

Figure 14 shows the levels of third-order intermodulation in an IC-706MKIIG at input levels in the range –56 to –8 dBm. As one can see from the measured data, third-order intermodulation shows accurate third-order behavior up to a point when it is about 40 dB below the two tones. To make this measurement, a nearly perfect two-tone generator was used. With the aid of the RX144 and Linrad, the source was verified to have IM3 far below the levels recorded for the IC-706MKIIG. It is, of course, essential that the source of the weak signal is very

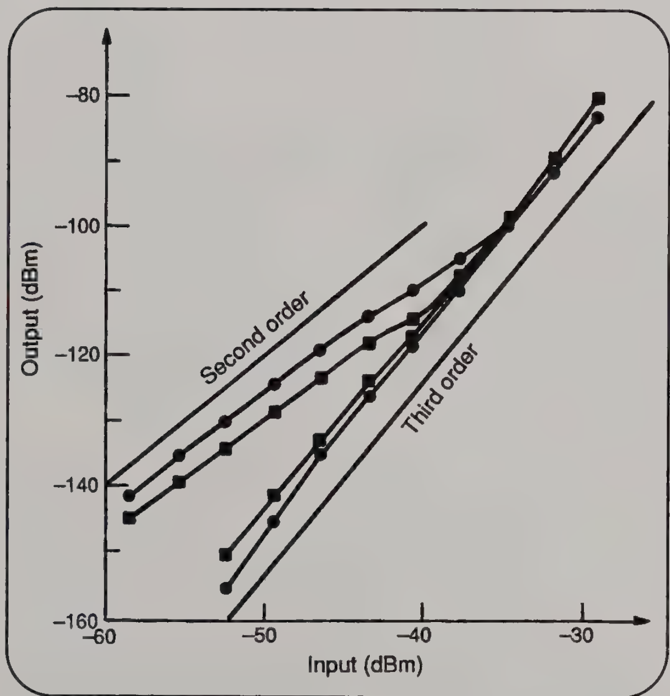

Figure 15. IM3 measurements on a BFR91A wideband amplifier. The upper (circles) and the lower (boxes) intermodulation frequency signal level with and without a filter that removes the second harmonics from the test signal. Note that presence of harmonics causes a second-order behavior at low levels.

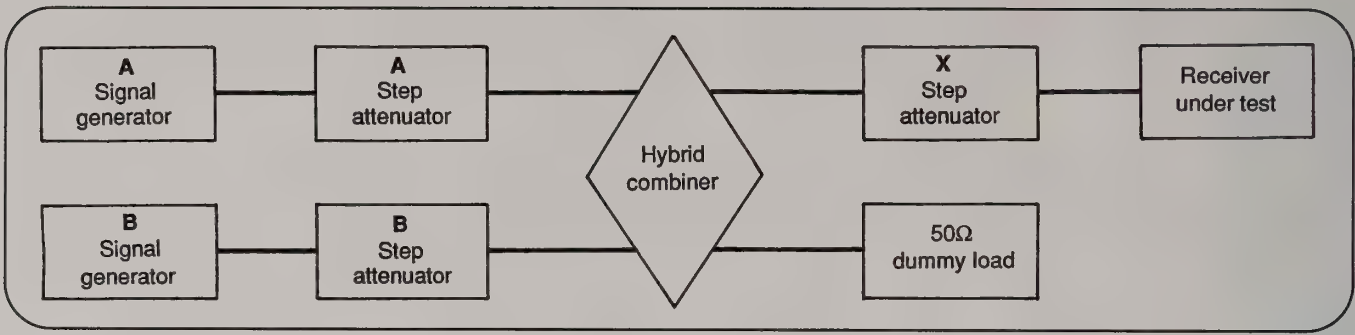

Figure 16. Two signal generators are combined and isolated from one another with a hybrid combiner (see text).

well screened. Any leakage will cause incorrect results at low levels of IM3.

The following sub-sections identify problem areas that need attention when combining two high-level signal generators to make a two-tone source for DR_3 measurements.

Signal-Generator Harmonics

First of all, the two signal generators that are to be combined need to be free of harmonics. If, for example, two generators at 144.100 and 144.125 are used, the third-order intermodulation products are expected at 144.075 and 144.150 MHz, respectively. If both generators have some signal at the second harmonic, difference frequencies 288.250 – 144.100 = 144.150 and 288.200 – 144.125 = 144.075 may be generated. The frequencies are exactly where the third-order intermodulation products will appear. Even worse, these difference frequencies are second order, so they do not fall off as rapidly as the third-order products. Therefore, the second-order products related to generator overtones may dominate at low levels of intermodulation.

To get an idea of what the consequences are, look at figure 15, which is a plot of the output from a wideband amplifier using BFR91A. Linrad with RX144 is used as a spectrum analyzer. The signal level and the levels at the two IM3 frequencies are measured directly with the Linrad S-meter. The input signal ranges from –29 dBm to –59 dBm. For these measurements, the signal generators were followed by deliberately saturated amplifiers that produced second harmonics about 25 dB below the main signals. At such a high harmonic content into a wideband amplifier, it is not surprising that the deviations from normal third-order behavior are rather large. For a comparison, figure 15 also shows data measured with a bandpass filter for 144 MHz inserted in the same setup to reduce the harmonics to about –75 dBc.

The wideband amplifier used to produce figure 15 has IP3 at about –4 dBm. It must be measured with input signals above –38 dBm when the harmonics are at –25 dBc. The third-order intermodulation products are then at about –107 dBm, which is about 40 dB above the noise in 2-kHz bandwidth. Trying to measure the third-order intermodulation-free dynamic range at the noise floor would give incorrect results.

Second harmonics of the test signals often will be suppressed by the input filters of the test receiver, but it is still a good idea to make sure the test signals are not polluted with harmonics, particularly if external amplifiers are used to raise the power level. More power makes it easier to combine two signals without intermodulation, but simple saturated amplifiers need lowpass or bandpass filters at the output. If the144-MHz notch filter described above is being used to remove noise sidebands, it also provides very good harmonic suppression at 288 MHz and above.

Mutual Intermodulation Between Generators

The two strong signals required for a DR_3 measurement are usually obtained by the arrangement shown in figure 16. A suitable hybrid combiner can be made from coaxial cable. Avoid ferrite transformers, as they may produce intermodulation. An iron-free hybrid combiner with built-in dummy load can also be made with coils, capacitors, and a resistor. The hybrid will isolate the inputs from one another by something like 30 or 40 dB if both outputs are terminated in 50 ohms.

Note that the receiver under test is actually not likely to have an input impedance of 50 ohms; although it is designed for good noise-figure and intermodulation characteristics when the source impedance is 50 ohms, this does not imply that the input impedance is 50 ohms. The input impedance of the IC-706MKIIG that I use as a reference for a typical modern rig has an input impedance at 145 MHz of 55 ohms and 18 pF. The input VSWR is 3.0 and the return loss is –6 dB. If such a receiver is connected directly to the hybrid, even a perfect hybrid would degrade the isolation between the generators only to 12 dB. For each dB of attenuation in front of the receiver under test, the isolation will improve by 2 dB until the isolation reaches 25 dB or so. The hybrid simply works as a VSWR bridge, and it measures the reflected wave from the receiver under test. Fifty percent of the power from generator A goes to the dummy load; 50% goes to the test port, comes back as a reflected wave, and is then split equally into generator A and B, which receive 25% each. Therefore, the reflected wave minus 6 dB is all the isolation one can get. For a given level of the test signal into the receiver, it does not matter if attenuation is made in front of the hybrid or after the hybrid, as long as the isolation provided by the hybrid is far from the limit.

When the output attenuator is set high enough, small impedance errors may cause large changes of the near-zero coupling between the generators. By fine-tuning the impedance of the dummy load, it is possible to cancel the coupling completely, but only from A to B or vice versa. The reason is that balancing is frequency dependent, but if the two generators are very closely spaced, balancing is a way of removing mutual intermodulation in the generators at high signal levels.

With good generators such as the HP8657A, worst-case intermodulation levels for the configuration of figure 16 are shown in figure 17. The figure shows measured intermodulation levels at different power levels into the test object, which is the same impedance as the IC-706MKIIG. The attenuator X is set to 3 dB, and the attenuators A and B are the attenuators built

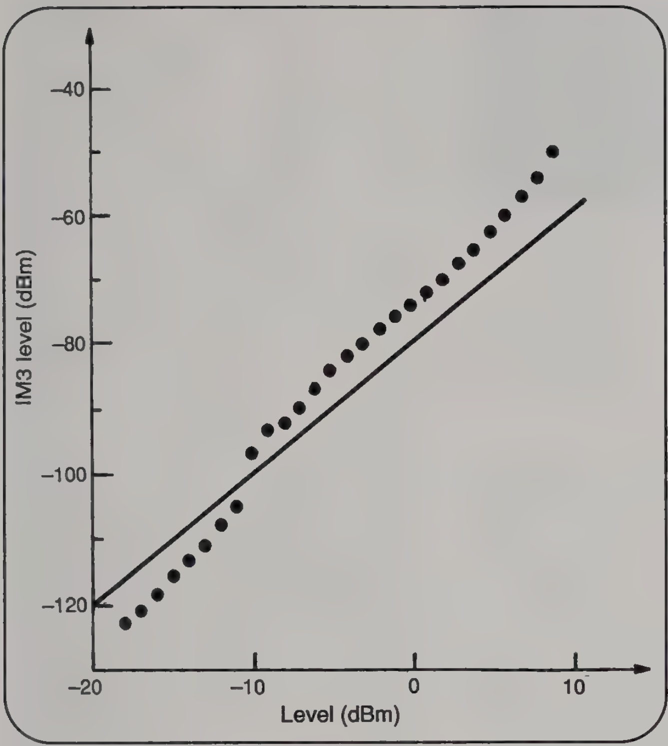

Figure 17. The intermodulation produced in a HP8657A when used for a two-tone test. The discontinuity between –10 and –11 dBm is between –3 dBm and –4 dBm power output from the signal generators. It is because of the internal architecture of the HP8657A generator.

into the generators. To make accurate measurements of low intermodulation levels, a directional coupler is inserted between generator A and the hybrid for the data in figure 17.

To generate an IMD product at the noise floor in SSB bandwidth, the IM3 product will need to be at about –130 dBm if a noise figure of about 10 dB is assumed. This calls for IM3 levels from the generator of less than –140 dBm. Extrapolating from figure 17, one finds that the maximum signal level that may be used is then about –30 dBm. This means that a pair of HP8657A generators can be used for IM3 measurements at the noise floor up to a third-order intercept point of about +20 dBm. An old vacuum- tube free-running oscillator, the HP608D, produces 12 dB more intermodulation than the HP8657A if it is properly calibrated. However, by turning the output-level control to maximum, one can get +13 dBm output power rather than the +4 dBm that is the maximum when the control is "properly" set. This means that 9 dB more attenuation can be used, and then the HP608D becomes better than the HP8657A, with IM3 about 7 dB lower.

It is a good idea to check what really comes out from the signal generators by the use of a directional coupler. If you do not have a good enough spectrum analyzer (RX144 + Linrad), you can use the receiver, which will later become the test object. The signal extracted from a directional coupler will have the signal from the other generator suppressed by something like 20 dB, but the IM3 product will be present on the opposite side in frequency and its level below the generator signal is the same as will be presented to the test object in the real test. In this case, the test object will produce at least 20 dB less IM3, since it is not loaded by equal signal levels at the two frequencies because of the directional coupler. With a second directional coupler and a third generator, one can measure the levels of signal and IM3 and make sure that the IM3 produced by the generator is well below the IM3 produced by the test object. Do not forget to allow the hybrid to see the same impedance as it will see later when the test object is connected to it. An open 3-dB pad will correspond to VSWR = 3 and may be used in the test port of the hybrid. Leave this 3-dB pad in place, and connect the test object after it to ensure the generator intermodulation will be smaller than the value you have checked.

It has been suggested that one can distribute the attenuation differently between attenuators in front of and after the hybrid to find out if there is a problem with IM3 produced in the generators. The idea is that the isolation provided by the hybrid will be constant, and that therefore the attenuators in front of the hybrid will affect the intermodulation produced in the generators, while the attenuator after the hybrid will not. This might be the case sometimes, but it certainly will not be true for a test object with an unmatched input, such as almost any low-noise VHF receiver.

To illustrate the effect of generator intermodulation, I have measured the IM3 levels of the IC-706MkIIG with two HP8657A generators set to +10 dBm connected directly to the hybrid. The test port of the hybrid is connected to a step attenuator and loaded by 18 pF to make the hybrid see VSWR = 3. The step attenuator is used to set the level of the test signal pair. The maximum available power level is +4 dBm. Figure 18 shows the result. As expected, the intermodulation shows first-order behavior at low signal levels where the intermodulation produced in the generators dominates.

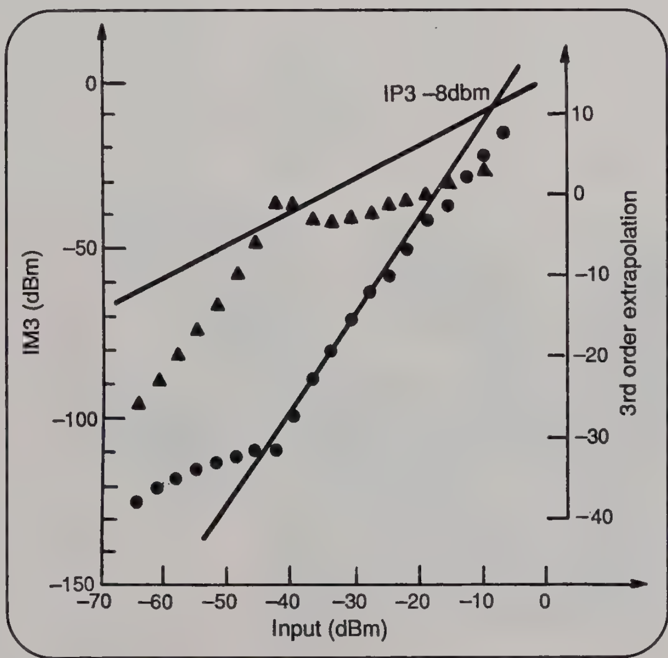

Figure 18. Measured level of third-order intermodulation (circles) for an IC-706MKIIG with RF amplifier off and with AGC enabled. This is the same measurement as in figure 14 but with poor isolation between generators. The formula for evaluating IP3 result (triangles) gives the correct result (IP3 = –8 dBm) in a narrow range only. At low levels the intermodulation in the generators dominates, and at high levels the receiver under test does not have third-order behavior.

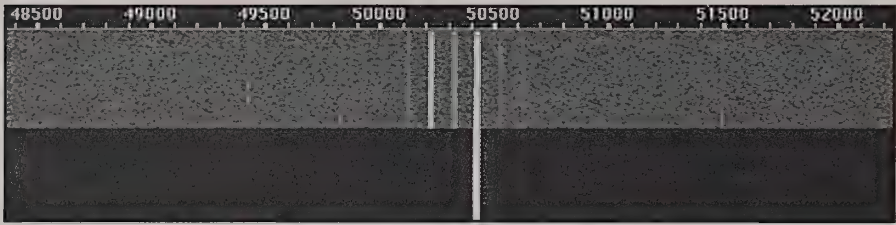

Figure 19. Two HP8657A generators at 143.9498 and 144.0499 produce IM3 at 144.1500 MHz (there is a calibration error of 430 Hz). The lower half of this waterfall graph is with the composite test signal through a notch filter. Only IM3 is visible. The upper half is without notch filter; spurs and sideband noise are not much below the IM3 product at –82 dBc. The HP8657A generators are not suitable for measuring IM3 lower than about –70 dBc without a spectrum analyzer and not lower than about –90 dBc without a notch filter

This measurement is intended to show a way of making an incorrect measurement and what the result might look like. Figure 18 is an extreme case of poor measurement engineering, where only the output attenuator is used to set the signal level. Obviously, the mismatch at the hybrid output will be much smaller in a real measurement; the 18-pF capacitance provokes a really bad VSWR. It is convenient to set the level of both generators simultaneously on the output attenuator X in figure 16. However, as soon as one reaches the point where isolation does not improve by the full return loss improvement (typically at an attenuation in the order of 10dB or less), it is much better to use the attenuators at the generator side.

If measurements are done without the aid of an audio spectrum analyzer, all sorts of further errors are possible. If modern (synthesized) generators are used, they are likely to have spurs every 10 kHz and/or every 100 kHz. Figure 19 shows the waterfall graph recorded from two HP8657A generators delivering –15 dBm into the RX144. The lower part of the image shows IM3 only, but the upper part of the image shows all the noise and spurs that became visible without the notch filter, which was used for the lower half. The loss of the filter was compensated for, so the level of the two strong signals was the same in both cases. Note the strong spurs 100 and 200 Hz below the intermodulation product. The generators, 100 kHz separated in frequency, were offset by 100 and 200 Hz to move the spurs away from the IM3 frequency. One has to check for these spurs by running one generator only because each strong spur belongs to one generator only. The notch filter removes spurs and lowers the noise floor, so it makes IM3 stand out clearly even at low IM3 levels. Note that IP3 is not exceptional for the RX144; it is only about +25 dBm, a level that is not difficult to reach taking into account the system noise figure of about 16 dB. A narrowband receiver is easily much better than this; measuring IP3 near the noise floor may be really difficult with top-performance receivers. If a third generator is not used, measuring IM3 well above the noise floor may be really difficult, too.

When class A power amplifiers are used to allow measurement at the noise floor of very good receivers, one needs to be extra careful with screening. Double-shielded coaxial cables and good connectors are needed to make sure there is no leakage causing intermodulation in the amplifiers. One also must make sure that connectors are clean and of good quality, because intermodulation may be produced in poor connections, switches of stepped attenuators, and elsewhere.

How Much DR Do We Need?

Based on surveys of actual signal levels at 7 MHz, Peter Chadwick, G3RZP (reference 11), arrived at the conclusion that PNDR (Phase Noise Limited Dynamic Range) should be at least 100 dB, and that ILDR (Intermodulation Limited Dynamic Range) should be at least 96 dB.

These numbers refer to an SSB bandwidth, and in the terminology I have used throughout this article, it means DR_2 should be at least 133 dB_{Hz} and DR_3 should be at least 129 dB_{Hz}.

On the VHF bands, the basic principles remain exactly the same, but the numbers are different. The needs will also vary much more at different locations. There are two kinds of problems: out-of-band interference and in-band interference. The out-of-band interference is typically at a large frequency separation, mainly FM and TV broadcast stations with very high effective radiated powers (ERPs). This is a problem for a preamplifier and filters associated with it. In-band interference from our fellow amateurs cannot easily be taken care of with filters, so here we need a good radio with high dynamic range.

On 144 MHz, amateurs typically produce power levels of 3 kW ERP with 100 W RF into a 13 dBd antenna, but ERPs of 100 kW are also not uncommon—1 kW into four modest Yagis with 18-dBd array

gain. The received powers at some different distances are given in Table 3 under the assumption of free-space propagation.

In reality, we do not have free-space conditions. Reflections from ground change the signal level in an unpredictable way, because the ground is typically not flat at all. Nevertheless, Table 3 indicates that a rig capable of dealing with –20-dBm power from neighboring amateurs would be useful at some locations. This translates to a DR_2 of 154 dB_{Hz}, which is possible, but nothing one can expect from standard transceivers today. Table 3 also shows that for two EME-grade stations at a distance of 1 km to work undisturbed with antennas pointing into one another, they would need a DR_2 of about 200 dB! That is impossible today and most probably will remain impossible.

Worst-case in-band interference at VHF typically is dominated by a single signal. It happens when you have your main lobe pointing toward the nearest neighbor while he is pointing in your direction. Contrary to the situation on the HF bands, the DR_2 requirements on VHF therefore may be far more stringent than the DR_3 requirements.

When testing receivers, one has to collect and present a large amount of data. It is relevant to measure DR_2 at several frequency separations, and a reasonable choice is 5, 20, 100, and 500 kHz. It would probably be enough to measure DR_3 at 5-, 20-, and 100-kHz separation, but the amount of data is still much larger than what is commonly published in product testing.

On the other hand, there is no reason to measure everything with and without a preamplifier, because the influence of a preamplifier should be easy to see: A preamp lowers IP3 by the amount of gain it has, and it reduces DR_3 by an amount given by the preamp gain minus the improvement in the noise figure. DR_2 should be affected only if it is limited by blocking, something that is uncommon in modern receivers. Within the limitations of available page space for reviews, it would be a good idea to focus product testing on the performance without the preamplifier, and simply specify the gain and noise-figure improvement obtainable by switching in the preamplifier. Additional measurements can always be posted on the web (which is already the ARRL's practice).

At VHF/UHF, an analysis of gain and dynamic-range performance will show that it is always better to use a mast-mounted preamplifier, and to operate the main receiver with its built-in preamplifier switched off. A serious VHF/UHF weak-signal enthusiast will always do this, so this is another reason for equipment reviews to focus mainly on the VHF/UHF performance data obtainable without the preamplifier. The noise from that preamplifier (including amplified antenna noise) should be the dominating contribution to the noise floor of the entire system. As a consequence, signal levels are raised by something like 15 dB, and this is another reason why dynamic-range requirements are much more difficult to meet at VHF/UHF, compared with HF bands where usually no preamplifier is needed. ■

Distance (km)	Tx ERP (kW)	Rx Ant = 13 dBd (dBm)	Rx Ant = 18 dBd (dBm)
1	3	+2.4	+7.4
1	100	+17.4	+22.4
10	3	–17.6	–12.6
10	100	–2.6	+2.4

Table 3. Received power levels with antennas pointing into one another on 144 MHz, at two different distances (assuming free-space propagation).

Correction to WB2AMU Article

In the article "July 2004—Very Different Conditions on the VHF Bands," by Ken Neubeck, WB2AMU, in the Fall 2004 issue of *CQ VHF,* there was a mixup in the figures. Figure 1 should have been keyed as figure 2 (see page 26 in the fall issue for an explanation of that figure), and figure 1 was left out. We are presenting figure 1 here with its correct caption.

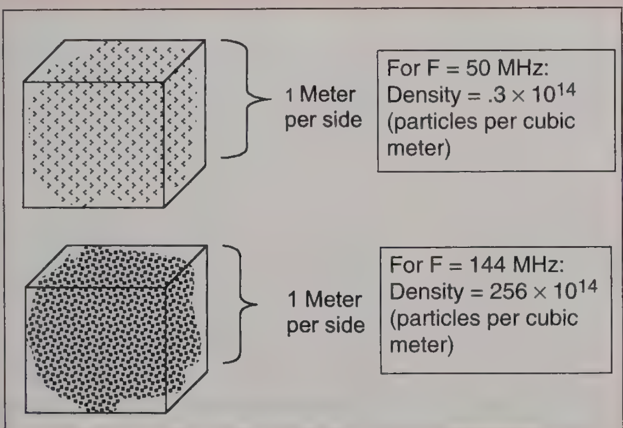

Figure 1. Pictorial description of electron density for sporadic-E formation. The figure provides a relative comparison between the different density levels of sporadic-E formation when they are capable of reflecting different VHF radio frequency signals. The calculations are based on the formula in the text of the article.

The Solar Hits Keep Coming in Cycle 23

Major aurora and auroral-*E* openings occurred in early November 2004. Here is WB2AMU's report on how VHFers took advantage of these conditions.

By Ken Neubeck,* WB2AMU

At the beginning of November 2004 a series of coronal mass ejections (CMEs) were observed coming from an active sunspot on the sun, resulting in a buckshot effect that happened to be Earth-directed. Indeed, even though we are on the downside of solar Cycle 23, with the overall sunspot count generally below 100 and the solar flux below 150, solar events are still occurring!

Major Aurora

As these events were Earth-directed, it was a matter of two days before the amateur radio bands were impacted by the subsequent geomagnetic activity. As expected, the impact of multiple CMEs on the Earth's geomagnetic field severely reduced HF activity. However, VHFers rejoiced at the potential aurora activity, and they were not to be disappointed.

The impact on the planetary *K*-index was noticeable over a three-day period, with the following three-hour intervals being recorded beginning at 0000Z:

November 8: 9 9 9 8 6 3 4 5
November 9: 6 6 5 7 6 7 8 7
November 10: 8 8 9 9 7 6 5 4

I was scheduled for a trip to Las Vegas with my XYL on November 8th, so I was busy packing, yet keeping an eye on the 6-meter chat page of DXer.info for any reports of aurora. When the reports started coming in, I took some time out to work stations on 6 meters from my location on Long Island, New York.

Signals on 6 meters were very strong, and I was hearing stations farther west than I normally do during an aurora opening. I was able to work KB8U in EN71 and NN9K in EN41, along with many other grids closer to me. At times some of the signals from the 8 and 9 call areas of the U.S. seemed to exhibit traces of auroral-*E* and were changing between aurora tones and auroral-*E* tones.

I was able to listen to 2 meters for a bit from my car, and I heard a number of CW stations with aurora tones from FM18. I even heard N9XG. As I was pressed for time, I really could not concentrate on operating and almost regretted leaving the northeast hot spot of aurora activity for the next few days!

Gordon West, WB6NOA, reported to me that very strong aurora signals from the northwestern states and western Canada were heard at his location in southern California on the 8th. There were even some paths into Hawaii that appeared to be auroral-*E*. Indeed, there were many auroral-*E* contacts made in the U.S. on the 8th and 10th in particu-

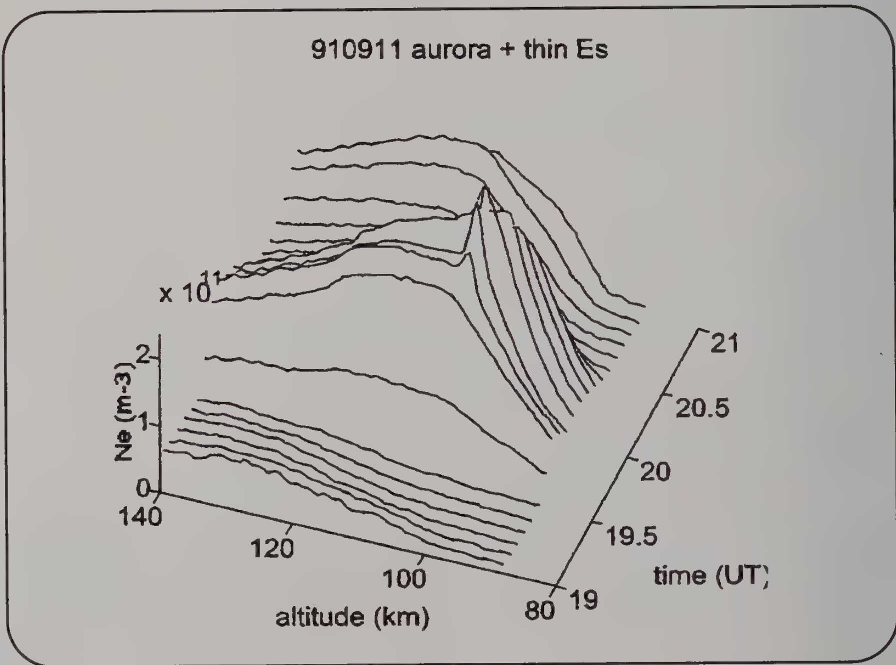

*Figure 1. The EISCAT radar plot from northern Europe shows the presence of a thin sporadic-*E *layer that is embedded inside a broad aurora formation. While not directly stated by EISCAT researchers, it is apparent that this thin* Es *layer is most likely what VHF operators observe as auroral-*E*. (Figure courtesy of S. Kirkwood)*

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lar, and it is worth exploring some of those contacts in detail.

Strong Auroral-*E* Openings

When there is a very strong aurora opening where the *K*-index reaches 8 or higher, the potential for follow-on events in the form of either auroral-*E* or north-south *F2* is always possible. For those two openings in November 2004, auroral-*E* was the primary event.

During the early-morning hours of the 8th, there were numerous auroral-*E* openings, primarily to the west for stations in New England. K7BV in FN31 worked KØGU in DN70 via an apparent auroral-*E* path. What was even more interesting was the path that Lefty, K1TOL, in southern Maine had to Europe at around 0300Z. It appeared to be a direct path with no auroral growl on it. Lefty was hearing strong aurora signals to the north and northwest, but to the east and northeast the signals were pure tone. The first indicator was a pure-tone VO1ZA beacon signal, and then about ten of the 48-MHz and 49-MHz European videos suddenly came rolling in. Lefty called one CQ and OZ4VV came right back to him; shortly thereafter he worked MMØAMW. Lefty was also heard in Sweden. The best guess that Lefty can make with regard to how this path was working was that it was multi-hop auroral-*E*, with the possibility that the signals might have been trapped above multiple formations, or the bending of the signals was just right! Indeed, the strong presence of auroral-*E* had many veteran 6-meter operators wondering about the long paths. Were the paths between Europe and Maine a true multi-hop path, or was it kind of like a chordal-hop path where the signal remained channeled in the *E*-region?

At 0700Z on the 10th, Dennis, K7BV/1, in FN31, was alerted by W1RA that Kevin, NL7Z, in Alaska was being heard in New England. Shortly thereafter, Dennis worked NL7Z on 50.110 MHz. Later NL7Z would be heard by Tom, WA2BPE, in FN12 at 0821, and by Bill, N8UUP, in EN82 as well as Dennis and Lefty.

As I stated before, I was making a trip to Las Vegas and I had brought along my portable FT-690 to see if there was any 6-meter activity related to the aurora at that location. I also had a cell phone that had Internet connection, so I continued to monitor the DXers.info chat page to view aurora activity. During late afternoon on November 10th I heard Al, K7ICW, in DM26 as well, and he was working VE4QZ (whom I could not hear too well) via an apparent auroral-*E* skip. I then managed to work Al, who told me that this was the first opening he had heard since the summer.

Summary

As discussed in previous articles in *CQ VHF*, it is observed by many VHF operators that when there is strong geomagnetic activity, sporadic-*E* is very rarely observed in the direction of the poles, where the activity is. However, auroral-*E* can result from a very strong aurora, and it has been picked up by EISCAT radar plots as shown in figure 1. Rocket launches into active auroras over Fort Churchill in Manitoba, Canada that took place over 30 years ago picked up the presence of metallic ions—typically magnesium ions—inside the active aurora.

Thus, there appears to be a very interesting relationship between aurora and sporadic-*E* ions. Does a very strong aurora help stimulate the formation of sporadic-*E* layers inside the aurora? While we have the EISCAT radar data to strongly suggest some kind of interaction, in the future we will need more observations and other new sources of scientific measurements to help answer this question and others.

Another item of note is the hot spot of the northeastern states of Maine and New Hampshire, as well as eastern Canada, with regard to different forms of 6-meter propagation. Not only does this area do well with *F2* propagation into Europe during the peak sunspot years, as well as multi-hop *Es* into Europe during the summer months, but auroral-*E* paths into Europe and Alaska seem to be reasonably possible as well. Even transequatorial propagation (TEP) is possible into this area with a sporadic-*E* link at the right times!

Can we expect any more geomagnetic events for the balance of Cycle 23? It would not be unreasonable to expect some additional events, most of them small, but based on past observations. A big event can occur at almost anytime during the solar cycle. Thus, it still will pay for VHF operators to continue to monitor 6 meters and above for the next year or so until the solar minimum arrives. We will continue to track and report any notable events on the pages of *CQ VHF*. ■

Flat Audio

There is no sweeter sound than clear, crisp audio. K6JSI tells how it can be achieved on your local repeater.

By Jeff (Shorty) Stouffer,* K6JSI

In this article we will start off with a quick "fly-by" description of just how audio works in FM two-way radio. We will briefly examine pre-emphasis and de-emphasis and repeater audio, and then we will discuss flat audio and how it differs from most repeater audio scenarios today. Later on we will delve into the details in more depth.

Here we go with the "fly-by" . . .

Fly-By

When frequency modulation (FM) began to be used in the late 1930s and early 1940s, it quickly became the preferred mode of radio communications, primarily because of its far superior signal-to-noise ratio and its ability to provide noise-free communications. At that time it was a one-radio to one-radio service, the same as what we call "simplex" today. Repeaters were not yet even dreamed of.

All early FM transmitters used phase modulation, which means they automatically doubled the deviation of an FM signal with every doubling of the audio frequency. This effect is called *pre-emphasis* and works as a 6 dB per octave increase in deviation, or a "roll-up" in deviation. It provided for a much better signal-to-noise ratio by making the higher frequencies have as much audio punch as the lower frequencies as it evened out the audio. The receivers of the day all had a *de-emphasis,* or a "roll-down" circuit, in them to restore the audio back to normal.

This is the way we still do it today, even with FM transmitters. FM transmitters have a pre-emphasis circuit built in, to be compatible with the existing phase-modulation (PM) transmitters, because all of the receivers out there are running de-emphasis circuits.

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When repeaters came along, hooking up the audio between the repeater RX and TX became a hotly contested topic, with many variations on how to do it. Some repeater builders took the user's pre-emphasized audio and de-emphasized it in the repeater RX, and then pre-emphasized it again in the repeater TX for delivery to the end user. Then the end user's receiver de-emphasized it again, thus returning the audio to normal. Whew! This probably could work out if all of the emphasis curves in the repeater are matched (a difficult task). Also, all the processing in the TX's speech amplifier affects the audio quality.

Another scenario is created when a mismatch occurs in a repeater because only one side of the repeater processes the audio. For instance, if there is an extra pre-emphasis stage in the repeater, the audio will sound very tinny and high-pitched—all highs with the lows missing. If there is an extra de-emphasis stage in the repeater, the audio will sound very mushy and lifeless—all lows with the highs missing.

Many repeater builders have different approaches—for instance, taking speaker audio and cramming it into microphone input. Ouch! Others try to run CTCSS on the repeater TX by just connecting the RX audio and the CTCSS encoder audio outputs together, thereby loading down both circuits and making everything sound mushy. Then when we begin to link repeaters together, it gets even worse, with all those link and repeater receivers and transmitters. Double ouch! There have been some really interesting lash-ups over the years with varying degrees of success and failure.

Flat Audio

When most of us talk about "flat audio," we are talking about passing audio through the repeater without any de-emphasis or pre-emphasis stages, or other audio processing in between. Since the audio is already pre-emphasized by the user's transmitter, you are not dealing with "flat audio" in the repeater anyway.

Taking the audio from the discriminator on the RX—where it is still pure and pre-emphasized by the user, before it is de-emphasized—we pass it through a controller and then inject it into the transmitter's audio chain well past the microphone input, past the speech amplifier, past the pre-emphasis network, and directly into the modulator. This keeps the audio "flat" through the repeater. Hence the term *flat audio.* This way the audio is un-modified as it works its way through the repeater. The RX leaves it alone, the controller leaves it alone, and the TX leaves it alone. The only audio shaping, or processing, is done at the user's transmitter and the end user's receiver, just like simplex.

There are two things that need to be addressed in this flat-audio scenario. They are:

1. A clipper (or limiter) in the TX audio chain, to limit the deviation of the transmitter; and
2. A low-pass audio filter past the clipper in the audio chain to eliminate the high-order harmonics produced in the clipping process (and to reduce the high-frequency noise—especially squelch bursts, generally up around 8000 Hz or so, that are very annoying to listen to in FM radio).

If these two items are not addressed, the repeater system, while sounding flat, will pass high-frequency noise and can produce very wide, over-deviated signals. It is important to stay within the 5-kHz deviation bandwidth with our repeaters and not over-deviate.

That was our quick "fly-by" of flat audio. Now we will delve into the subject in more detail, with a thorough description of how it really works.

What is Modulation?

Just over a hundred years ago, back in 1902, Fessenden developed a system to modulate a continuous wave with the human voice. Prior to that, most voice transmissions were attempts at modulating spark transmitters, with generally poor results.

Modulation is a mixing process. When RF and audio frequencies are combined in a standard amplitude modulation (AM) transmitter (such as one used for commercial broadcasting), four output signals are generated: the original carrier or RF signal; the original audio signal; and two sidebands, the frequencies of which are the sum and difference of the original RF and audio signals, and the amplitudes of which are proportional to that of the original audio signal. The RF envelope (sum of the sidebands and carrier), as viewed on an oscilloscope, has the shape of the modulating waveform.

The bandwidth of an AM signal is twice the highest audio frequency component of the modulating wave. Thus, if the highest audio frequency is 3000 Hz, the occupied bandwidth of an AM signal will be double that, or 6 kHz wide.

Frequency modulation (FM) was first technically addressed by John R. Carson in the February 1922 issue of the *Proceedings of the IRE* journal. By mathematical analysis, he "proved" FM inferior to AM on two counts: bandwidth requirements and distortion.

The Carson analysis held until May 1936, when another paper on FM appeared in the same journal. In this work, Major Edwin H. Armstrong set the stage for a new viable FM mode of communications. The basic theory behind his ideas is still in use today!

A Little History

We will start off with a little history of NBFM, or Narrow Band Frequency Modulation.

Methods of radiotelephone communication by frequency modulation were developed in the late 1930s by Major Edwin Armstrong in an attempt to reduce the problems of static and noise associated with receiving AM broadcast transmissions of the day. The real advantage of FM—its ability to produce high-quality signal-to-noise-ratio audio when receiving a signal of only moderate strength—has made FM the preferred mode of choice for mobile communication services and quality broadcasting.

With AM and SSB, the very process of demodulating audio causes the receiver to be looking for changes in amplitude. Therefore, any static or noise is recovered in the receiver along with the audio. When FM was first introduced, the main selling point of the new mode was that noise-free voice reception was finally possible. This is still very true today. FM inherently has a much better signal-to-noise ratio than AM. That is one of the reasons why FM sounds so good, compared to an equivalent AM or SSB signal.

The disadvantages of FM are few, most notably its wider bandwidth requirement. By way of example, a 5-kHz deviated FM signal with an audio (voice) frequency of 3000 Hz occupies about 16 kHz of radio spectrum. Compare this to AM, which occupies about 6 kHz of radio spectrum for the same 3000 Hz of audio, and less spectrum (about half) for an equivalent SSB signal.

This is one reason why FM is most popular in the VHF and UHF regions, where spectrum is more available. For the Amateur Radio Service, the FCC limits the low end of FM to 29.500 MHz. On the high-frequency amateur bands, 80 through 10 meters, single sideband is the most widely used radiotelephony mode, partly because it occupies comparatively less spectrum, which is important for frequencies that travel by skywave.

Audio Frequencies

We'll leave the radio world for now, and enter the audio world. In today's FM two-way radio communications, the audio frequencies we utilize for voice are between 300 and 3000 Hz. Another way of stating it is that frequencies between 300 and 3000 Hz are the "audio range" or "voice band" of frequencies. The sub-audible, or CTCSS (PL), frequencies in FM are well below 300 Hz and will be discussed in another section.

To understand just what the "audio band" of frequencies is, let's think about the piano for a moment. Most of us know what "Middle C" sounds like; that's the white key in the middle of the keyboard just to the left of the two black keys. If you have a piano nearby, it may be helpful to sit at it and try this little exercise. If not, try to imagine how the notes sound from memory.

Play the Middle C key. Middle C is technically called C4, as it is the fourth "C" from the bottom (left-hand end) of the keyboard. Middle C, or C4, has a frequency of 261.63 Hz if the piano is tuned properly. That's right, 261 Hz. It is even a little lower than our 300-Hz low-end cut-off limit of the FM audio spectrum described above. It is technically in the sub-audible frequency range, because it is below the voice band, although most of us can still hear it, can't we? That is why you don't see many PLs above 200 Hz—and that is because you can actually hear them. Most PLs are usually around 100 Hz or so. More on PLs later.

Now let's get back to our piano exercise. If you go up one octave on the piano to the C that is 12 keys higher (both black and white keys) and play that key, the frequency will be 523 Hz. This is called C5. Notice that it is twice the frequency of C4 (261 Hz × 2 = 523 Hz). This difference is called one "octave." An octave is defined as follows: A one-octave separation occurs when the higher frequency is twice the lower frequency. Thus, the octave ratio is 2:1. Every time you double the frequency, you go up one octave in frequency.

Moving to the next higher octave, or to the next "C," which is called C6, play it and the frequency will be 1046 Hz. This is twice the frequency of C5. Play the next higher octave, which is C7, and the frequency will be 2093 Hz. This is again twice the frequency of C6.

The upper limit of our "audio range" in FM is 3000 Hz, and the closest piano key for that frequency is the highest F# (F sharp) on the piano, which is the very left-hand black key of the last set of three black keys on the keyboard, or the seventh key from the top (right-hand end) of the keyboard. The frequency of F# is 2960 Hz.

Therefore, when I say that the audio frequencies used in our modern-day FM radios are from 300 to 3000 Hz, I am saying that the frequency range is the same as playing the piano keys from Middle D, or D4 (296.66 Hz), to the highest F#, or F#7 (2960 Hz).

Speech

Now let's talk a little about how this audio-frequency business translates into communication.

Human speech is an interesting subject. Speech is comprised of multiple audio frequencies, mostly in the 125- to 4000-Hz

range. However, all frequencies are not created equal in human speech. Some frequencies are louder than others, and some carry more intelligence than others. Here are a couple of facts concerning audio frequencies and human speech:

Fact Number One: The lower frequencies, those between 125 and 500 Hz, contain about 55 percent of the speech energy. However, they only contribute about 4 percent to speech intelligibility.

Fact Number Two: The higher frequencies, those between 1000 and 4000 Hz, contain only about 4 percent of the total speech energy, but contribute an amazing 50 percent to speech intelligibility.

To *understand* human speech, though, we actually need to hear the higher frequencies (above 1000 Hz) *more than* the lower frequencies, as that is where about *half* the speech intelligibility is contained. Interesting, isn't it? Thus, when a radio manufacturer says it is producing a "communications quality" radio, what frequencies do you think it is enhancing? Why, the high frequencies, of course, as that is where over 50 percent of the speech intelligibility is.

Frequency Modulation Defined

Now let's get back to radio. We now understand that over half of the speech *energy* is contained below 500 Hz when we are transmitting FM. Therefore, it normally follows that the amplitude of the lower frequencies is going to be much greater than the amplitude of the higher frequencies.

Let's step back for a moment and define what FM is. When a modulating voice signal is applied to an FM modulator, the carrier frequency is increased during one half-cycle of the modulating signal and decreased during the half-cycle of the opposing polarity. In other words, the carrier frequency of our transmitter varies at an audio rate above and below our carrier frequency according to what the amplitude of the audio voice signal is.

Therefore, to define frequency modulation, or FM, we would say: *The change in the carrier frequency is proportional to the instantaneous amplitude of the modulating signal.*

Amplitude, then, is what drives FM. It thus follows that if 55 percent of the amplitude energy is contained in the voice frequencies below 500 Hz, then a true FM transmitter is putting 55 percent of its energy, or its power, into the lower audio frequencies. That is where only 4 percent of speech intelligibility resides.

Also, by the same logic, the same true FM transmitter is only putting 4 percent of its energy, or power, into the voice frequencies above 1000 Hz, and that is where over 50 percent of the speech intelligibility is, remember? This means that if you listen to a true FM transmitter, with 55 percent of its power in the voice band below 500 Hz, it will sound very mushy, almost all bass or low frequencies with hardly any high-frequency component at all.

Phase Modulation Defined

Next let's define phase modulation, or PM. It is possible to convey intelligence by modulating any property of a carrier, including its frequency and phase. When the frequency of the carrier is varied in accordance with the amplitude variations in a modulating signal, the result is frequency modulation, or FM.

Similarly, varying the phase of the carrier current is called *phase modulation.* Frequency and phase modulation are not independent, since the frequency cannot be varied without also varying the phase, and vice versa. In other words, phase is the mathematical derivative of frequency.

If the phase of the current in a circuit shifts, there is an instantaneous frequency change during the time that the phase is shifting. The amount of frequency change, or deviation, is directly proportional to how rapidly the phase is shifting and the total amount of the phase shift. The rapidity of the phase shift is directly proportional to the frequency of the modulating signal. Further, in a properly operating PM system the amount of phase shift is proportional to the instantaneous amplitude of the modulating signal.

Therefore, to define PM we would say: *The change in the carrier frequency is proportional to both the instantaneous voltage and the frequency of the modulating signal.* This is the outstanding difference between FM and PM, since in FM the frequency deviation is proportional *only* to the amplitude of the modulating signal.

By contrast, in PM the deviation increases with *both* the instantaneous amplitude *and* the frequency of the modulating signal. This means that PM has a built-in pre-emphasis, where the deviation increases with modulation frequency. Apart from this difference, when receiving FM or PM it is difficult to distinguish between the two.

Notice I used the word *pre-emphasis* above. This is probably a good place to explain how pre-emphasis and de-emphasis work.

Pre-Emphasis and De-Emphasis

What is pre-emphasis? Pre-emphasis follows a 6-dB per octave boost rate. This means that as the audio frequency doubles, the amplitude (and deviation) doubles (by 6 dB). Thus, with pre-emphasis the following examples are typical of pre-emphasis on an FM transmitter's deviation:

- a 500-Hz audio tone will make 1 kHz of deviation
- a 1000-Hz audio tone will make 2 kHz of deviation
- a 2000-Hz audio tone will make 4 kHz of deviation

Why do we even have pre-emphasis in NBFM communications? There are actually two reasons:

1. The early transmitters were really PM, not FM, so they naturally had a 6-dB/octave "roll-up" or pre-emphasis. PM was the standard modulation method. When FM transmitters came along, their audio had to be intentionally pre-emphasized to maintain compatibility with the PM transmitters already in service. In very early narrowband literature you won't even find the terms *pre-emphasis* and *de-emphasis.* Engineers simply "rolled-off" the audio in the receiver with a single-pole filter to reverse the PM transmitter's "roll-up" characteristic and restore the transmitted audio back to normal.
2. Pre-emphasis is needed in FM to maintain a good signal-to-noise ratio across the entire voice band. Theory tells us that white noise increases with frequency at a receiver discriminator. When de-emphasis is added to a receiver this noise is attenuated, thus improving the signal-to-noise ratio.

Pre-emphasis is used to shape the voice signals with the increased level of the higher frequencies being applied to the modulator, which results in a better transmitted audio signal-to-noise ratio due to the highs being above the noise as much or more than the lows. The accompanying graph (figure 1) illustrates the pre-

emphasis curve, audio frequencies along the bottom.

We must recognize that early narrow-band FM radio was intended for one-transmitter/one-receiver applications. This business of repeaters and linking repeaters came much later. Virtually all FM radios today, including commercial broadcast, use pre-emphasized and de-emphasized audio. When you talk with someone on simplex, the TX pre-emphasizes his or her audio. If you could listen to "raw" pre-emphasized audio, it would sound very tinny, mostly highs. However, your receiver de-emphasizes the audio, returning it back to normal.

By contrast, if you could listen to "raw" FM audio, it would sound almost all bass (or low frequencies), as most of the amplitude (or energy) is in the low-frequency range with hardly any highs (or treble) at all. The higher frequencies would be more in the noise, as their amplitude would be much less and would be virtually not readable.

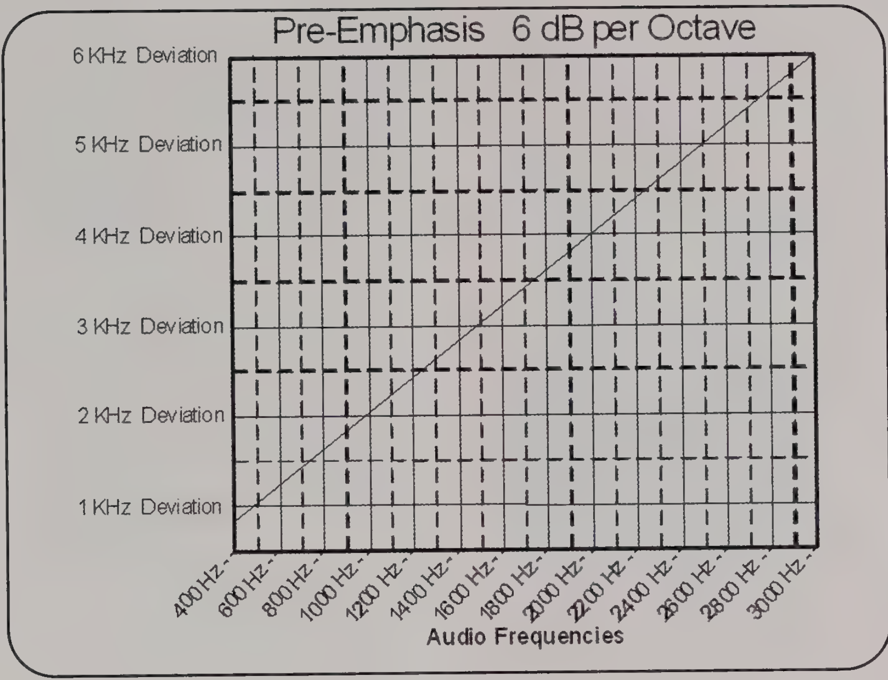


Figure 1. The pre-emphasis curve, with audio frequencies shown along the bottom.

Signal-to-Noise Ratio

This is a ratio that defines the ability to demodulate, or recover, the audio of a radio signal. This is one of the best advantages of FM over any other form of modulation.

Noise is an ever-present part of radio communications. If you aren't aware of this phenomenon, tune to the low bands with a communications receiver, from, say, 160 to 10 meters, and simply tune across the band. What you hear is noise . . . lots of noise! Hopefully, if you're lucky (if the band is "in"), as you tune across, say, 20 meters (14.000 to 14.300 MHz), the noise occasionally will be interrupted by signals. If you're *really* lucky, some of the signals will be loud enough to overcome most of the noise. You are experiencing signal-to-noise at its finest. This is a low signal-to-noise-ratio situation.

In FM, when a sufficient signal arrives at the receiver, the signal quiets—that is, because of the high RF limiter, the background noise disappears. Completely. This differs greatly from AM on the low bands, because most natural-occurring noise is amplitude modulated and noise is ever present. In FM, unless the station you're talking to is very weak and barely making it, there will be no noise at all on the signal. This is a high signal-to-noise-ratio situation.

In fact, the sensitivity of an FM receiver is rated in terms of the amount of input signal required to produce a given amount of *quieting,* usually 20 dB. The use of solid-state devices allows modern FM receivers to achieve 20-dB quieting with only 0.15 to 0.10 µv of input signal.

Therefore, the big difference between the AM or SSB on the low bands and FM communications is the amount of noise you must listen to while communicating. The lower the amount of noise on a signal, the better the signal-to-noise ratio.

Speech Clipper

A clipper, or limiter, is a safety valve that limits the peak deviation of an FM or PM transmitter. In broadcast it is sometimes referred to as a *safety clipper.* It keeps the deviation down to a pre-set level, usually 5 kHz for land-mobile communications.

Because the modulation index, or bandwidth, of the transmitted pre-emphasized FM signal increases with the modulation audio frequency, it can easily exceed 3000 Hz. For example, if a long squelch tail is re-transmitted through a repeater, that audio frequency is usually somewhere up around 8000 Hz. This means that the maximum deviation of 5 kHz can easily be exceeded. In the case of the 8000-Hz squelch noise, a deviation of 8 kHz is possible. Deviation that wide would surely ingress into adjacent channel repeaters.

Not only do these wider deviated signals go outside the normal bandwidth of most receivers and cut off the audio (as they over-deviate past the capability of the receiver to demodulate the audio), but more important, these wider sidebands can interfere with other adjacent-channel repeaters and radios. Therefore, it is necessary that some sort of frequency clipping or limiting be placed between the audio source and the modulator. This clipper or limiter should provide clipping at about 5 kHz of transmitter deviation.

Low-Pass Audio Filter

The clipping process produces high-order harmonics, which, if allowed to pass through to the modulator stage, would create unwanted sidebands. Therefore, an audio low-pass filter with a cut-off frequency between 2600 Hz and 3000 Hz is needed at the output of the clipper. This keeps the harmonics, and other high-frequency noise (such as squelch noise), out of the transmitter. This also keeps the occasional long squelch tail, or blast of white noise, from being heard so loudly. Oh, you can still hear these noises, but their amplitude is far lower than without a low-pass filter.

Sub-Audible Frequencies

Sub-audible tones are frequently used to limit access and are commonly called *PL* (a Motorola term that stands for Private Line) or *CG* (a General Electric term for Channel Guard). But whatever name you apply to the sub-audible tone,

it simply describes CTCSS, or Continuous Tone Coded Squelch Systems.

This is a continuous tone that is sent along with the transmitted signal at a much lower volume (I usually have it at 0.4-kHz deviation) and at a lower (sub-audible) frequency that you hopefully will not be able to hear really well. This is called *encoding*. It simply means that you are transmitting this continuous tone along with your normal speech in the transmitter.

Decoding is where your receiver hears the continuous CTCSS tone and "decodes" the tone, thereby opening your receiver's squelch so it can hear your transmitted audio.

These frequencies are much lower in frequency than normal, usually around 100.0 Hz. The lowest CTCSS frequency on most radios is about 67.0 Hz, and the highest is about 254.1 Hz.

More on Flat Audio

Now that you are becoming experts in the audio and modulation arenas, I will explain *flat audio*.

As we have discussed previously, early FM radios were designed to be one-radio to one-radio devices. Also, to improve the signal-to-noise ratio, they were all PM transmitters with the built-in audio "roll-up," or pre-emphasis, of 6 dB per octave. This made the signal-to-noise ratio better for reception, making the high frequencies usually as strong as the lows. The receivers all had the audio "roll-down," or de-emphasis, network to restore the audio back to its original state. Everything worked great.

Enter repeaters. Repeaters extended the range of one-radio to one-radio communications. If they were high enough above average terrain, they greatly extended the range. However, because repeaters are duplex and the RX repeats the audio it hears to the TX, there are issues with audio quality and the processing of the audio.

There are many different ways to hook up the audio in repeaters. Some repeater builders take speaker audio out of the receiver and connect it to the microphone input on the transmitter. This has several ramifications:

1. The RX speaker audio will be de-emphasized (again) by the repeater RX.
2. The RX speaker audio is almost always shaped or processed somewhat to match the speaker that the manufacturer specified to be used with the RX.
3. The speaker audio is almost always amplified well beyond what the microphone requires, usually somewhere between 3 to 5 watts of audio power. The microphone needs milliwatts of audio power. Some audio distortion will most likely be present in the amplification, typically 10 percent, and noise is amplified as well.
4. What is the impedance of the average speaker? 4 ohms? 8 ohms?
5. The squelch crash after a user stops transmitting will always be passed along through the audio chain from the repeater RX speaker. You are at the mercy of whatever squelch circuit the repeater RX is using.
6. The TX microphone input audio is always shaped by the manufacturer to match whatever kind of microphone element it is using, be it crystal, dynamic, cardioid, or ceramic. This is usually called the *speech amplifier*. The bottom line is that the audio is shaped, or processed, to match the microphone element. If the mic input is used, this shaping has an effect on the audio coming out of the repeater TX.
7. The audio is pre-emphasized (again) in the repeater TX.
8. The audio input impedance is usually several thousand ohms, not the 4 ohms or 8 ohms of a speaker. If a controller, emitter follower, or cathode follower is used, the impedance mismatch can probably be overcome.
9. Once you set the volume-, squelch-, and modulation-level knobs on the repeater, you'd better not touch them again or your repeat audio levels will go crazy. If someone accidentally bumps one while near the repeater, you'll know right away.

As you can see, this method leaves a lot to be desired. Why do folks do it? Because it's easy! There is not much work involved in strapping a speaker to a microphone. However, if you're willing to invest the time, there are better ways to get the audio from the receiver to the transmitter. Some folks have become very clever at this.

One more point: As we've discussed before, the audio from the user's transmitter is already pre-emphasized, isn't it? It enters the repeater RX pre-emphasized. If the repeater RX de-emphasizes it and then the repeater TX pre-emphasizes it again, in theory it should sound about the same coming out of the repeater TX. However, it usually doesn't. One reason is because the de-emphasis and pre-emphasis curves in the repeater RX and TX are usually not exactly the same. They

don't track one another perfectly. There is usually a difference.

It is much better to leave the audio alone when going through a repeater and not process it, keeping the repeater audio path linear. The originating audio is pre-emphasized by the user's transmitter, and we let it be de-emphasized in the end user's receiver. This is the way it is done on simplex, without a repeater in-between. This is what flat audio is.

Another way of saying it is as follows: When the repeater RX hears a signal, it leaves the audio alone, or keeps it flat, without any changes. Likewise, the controller should leave it alone, with no changes. Finally, the repeater TX should leave it alone, without adding anything to it. That way, as far as the audio is concerned the repeater was never there, because the audio path is flat through the repeater. It has not been de-emphasized, shaped, pre-emphasized, and shaped again. It is flat. No processing. No changes.

How one accomplishes this flat audio is really pretty simple. Here is a quick run-down:

1. Pick off the audio at the discriminator of the receiver. Usually the top (high side) of the squelch pot is a good starting point. This is where you can find discriminator noise with an oscilloscope.

2. Use a fast-acting, noise-free squelch circuit such as the Motorola MICOR squelch chip or a microprocessor-controlled digital squelch board (more on this digital squelch in a subsequent article).

3. If your controller gives you a choice, set the controller's input for flat audio.

4. Inject the audio well past the microphone input, past the speech-amplifier circuitry, and past the pre-emphasis network in the repeater TX. This point is usually at the PL, or CTCSS, injection point. This is usually past the TX's built-in clipper and low-pass filter, too, as they are typically in the low-level audio stages of the exciter.

If proper impedance techniques are used this will result in flat audio. It will sound great. However, you really need to install your own clipper to keep your transmitter from over-deviating. Also, you need to install your own low-pass filter to keep the harmonics and high-frequency noise out of your transmitted audio. Finally, and very important, all stages in the repeat audio path must be designed with adequate headroom, or dynamic range.

Also, if you plan to run CTCSS on the transmitter output, you need an isolated input for the CTCSS encoder so it won't load down your audio circuitry, making it sound mushy.

Furthermore, if you are using a PM transmitter—say, a GE or most Japanese radios—you need to be able to compensate for its natural pre-emphasis, or "roll-up" characteristics. This means you need to shape the audio going to the TX to reverse the pre-emphasis roll-up.

Finally, when adjusting audio levels in a repeater, quite often the RX has too little audio level—or too much level—available at the discriminator. Similarly, some transmitters need more audio drive than others at the CTCSS input location. Many controllers cannot handle big variations in audio input and output levels, so you must build op-amps to balance the levels.

Thanks for taking the time to read this article on quality audio. It is my hope that more repeater builders will take the time to make their audio sound fantastic. It can be done with ease. Please direct any question or comments to me at the e-mail address shown at the beginning of this article. ■

By John Champa,* K8OCL

HSMM

Communicating Voice, Video, and Data with Amateur Radio

S.H.A.R.K.s and Tsunamis

This column is on the easy use of Amateur High Speed Multimedia (HSMM) radio in an emergency. HSMM radio is packet radio, but thousands of times faster. It is so fast that we can use simultaneous voice, data, text, and video modes. What a godsend this can be for hams working in a disaster area, such as the world is now facing in the aftermath of the tsunamis in Asia.

Walt DuBose, K5YFW, the ARRL's HSMM Working Group Assistant Chairman, reported the following on January 4:

> The Texas Baptist Men are deploying four or five water-purification units and three feeding units. They will likely want our Command, Control, and Communications unit next (that's my crew and me), but we will need State Department appointments to do our work and use ham frequencies. There is already talk of needing 802.11b links between communications centers and the various distribution points, using an AP *(access point—ed.)* that is high up on a mountain.

The accompanying sidebar contains their recommended packing list.

HSMM Radio—The Future

There are a number of significant reasons why HSMM radio is the wave of the future for many Emergency Communications (EmComm) situations such as those encountered by RACES, ARES, and other radio amateurs responding to disaster locations. These reasons include:

1. The amount of digital radio traffic on our 2.4-GHz band, presently the most common band used by hams for HSMM radio, is increasing. Operating under low-power, unlicensed Part 15 limitations cannot overcome this noise.

2. Higher power is sometimes needed for longer range, higher reliability, and high data-speed links (i.e., improved signal margins), so operating under Part 97 makes sense.

3. EmComm organizations increasingly need high-speed radio networks that can get vast amounts of data out of a disaster area and into an area where ADSL, cable modem, satellite, or other broadband Internet access is available.

4. The equipment needed by hams is readily available, highly economical, and easily adaptable, commercial off-the-shelf (COTS) gear of the IEEE 802.11b variety.

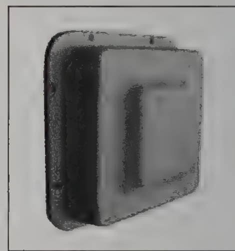
With HSMM radio, all that would be

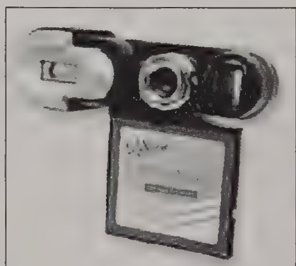
*Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458
e-mail: <k8ocl@arrl.net>

S.H.A.R.K. Components

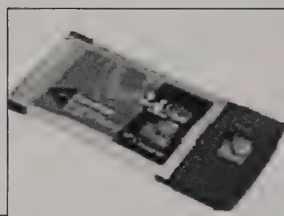

PDA & Extended Battery


Tripod Mount

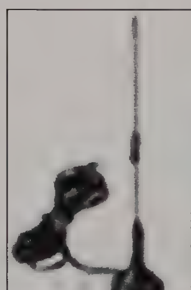

Antenna

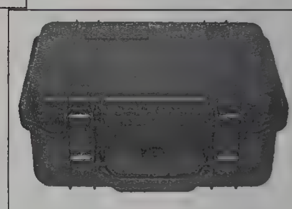

PDA Video Camera


USB Camera


Access Cards (2)


Access Point


Magnet Mount Antenna


Carrying Case


Outlet Strip

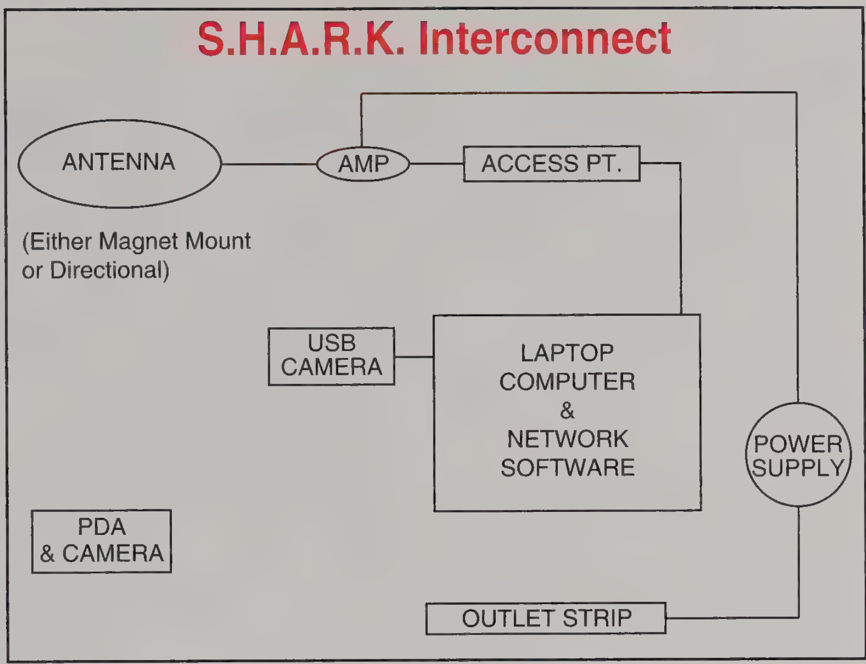

Power Amp


Laptop Computer

- Standard kit for deployment in emergency
- Easily field adaptable
- Video/file transfer operation
- Kit includes documentation, forms, etc.
- Includes PDA to allow handheld roaming
- Includes both omni & directional antenna

needed for such emergency communications in the field is a laptop computer with a headset for simultaneous voice and data modes. A digital camera can also be attached for simultaneous Amateur Digital Video (ADV) modes.

The laptop must be equipped with a special wireless local area network card (PC card) *with* an external antenna jack. Connect the PC card via a short strain-relief cable (a.k.a. pigtail) to some good coaxial cable (e.g., LMR-400) to a short Yagi antenna (typically 18 inches of antenna boom length) or a small mast-mounted dish antenna. That's all there is to it!



Oklahoma Baptist Hams Emergency List

Make a plan for sleeping in the open in an insect-infested area. Here is a list of possibilities items to include in your plan.

- Personal tent (pop-up, fully enclosed, zippered door)
- Inflatable mattress (that, of course, would fit in the tent)
- Sleeping bag
- Pillow
- Sheets
- Mosquito netting
- Insect repellant
- Clothing suitable for the climate
- TBM uniforms (caps, blue shirts, jackets, and so on)
- Boots
- Plenty of socks and underwear
- Long, sturdy pants
- Over-the-counter medications
- Any prescribed medications (at least a four-week supply)
- Melatonin (a natural sleep aid that will help shake off jet lag)
- Imodium
- Laxative
- Perhaps an antibiotic (your doctor may prescribe an overseas travel kit that includes this item)
- Maximum-size luggage (We need as much space for carrying the items needed for water purification as you can provide us.)
- Personal hygiene items
  - Soap
  - Toothpaste and toothbrush
  - Shaving kit
  - Manicure set
  - Brush or comb
  - Bath towels
  - Wash cloth
  - Shampoo
- Your *Bible*
- Items Not to Take!

  Anything you are not willing to leave behind and cell phone

Next point the antenna to the HSMM radio repeater at the Emergency Operating Center. Ranges from several miles to 20 miles and more over open water are readily possible. Date rates can be as high as 11 million bits per second (Mbps). The actual throughput is less, because the system is operating in half-duplex mode. This is *radio*, not your local cable modem, so the radios must stop transmitting between packet clusters to listen from time to time.

The S.H.A.R.K.

Here is where the S.H.A.R.K. comes in. S.H.A.R.K. stands for Standard HSMM Amateur Radio Kit. It is the brainchild of Jim Kvochick, WB8AZP (wb8azp@arrl.net), and Brandon Field, KC8YHE, and others in the wonderful and very friendly Livingston (Michigan County) Amateur Radio Klub (LARK).

Both Jim and Brandon are associated with the ARRL's HSMM Working Group (http://www.arrl.org/hsmm/). If you have any questions about high-speed digital or multimedia operation, the HSMM Working Group can help you get started in this exciting part of amateur radio. You can subscribe to the ARRL IEEE 802.11b Mail List at Texas A & M University. To subscribe, go to: <http://listserv.tamu.edu/archives/arrl-80211b.html> and select "Join" or *leave the list* (or *change settings*), or send an e-mail to <listserv@listserv.tamu.edu> and in the body put subscribe arrl-80211b [first name last name], or subscribe arrl-80211b [first name last name-callsign].

This list has been established to facilitate discussions of the various aspects of the HSMM and IEEE 802.11b/g with members of the ARRL HSMM WG and other interested parties. The IEEE 802.11b used by hams employs commercial 802.11b hardware, and additional legal amateur radio hardware such as RF amplifiers and high-gain directional antennas, which are appropriate for Part 97 service. All participants are welcomed to the list.

The photos and diagrams with this column are fairly self-explanatory, but what Jim and Brandon have created is a portable HSMM radio field station in a weatherproof transport container. It is available for immediate deployment, and in the hands of a qualified ham it can provide a high-speed Internet connection for simultaneous digital voice, data, and video within minutes of arriving at the scene of a disaster.

Jim and Brandon have shown us one way in which the mission of supplying emergency communications can be accomplished. Generally speaking, hams have the skills to deploy such HSMM radio systems. What they need is the knowledge base for operating these radio systems, and it can be fairly easily acquired by participating in the list and/or interacting with other participants on the list. ■

By Gary Pearce,* KN4AQ

FM

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

The State of Frequency Coordination, Part 1

Last year I spent a great deal of time trying to pull together the research I need to write a good column on the state of frequency coordination. I just haven't been trying very hard to actually *write* it, though. Thus, I'll get Part 1 started, and that may spur me on to buckle down and do Part 2 (and 3, 4, 5…). Maybe it will inspire a few of you to contribute your thoughts as well.

Part 1 is a short history of frequency coordination. I've been active on FM since the late 1960s. I was a teenager then, and the big wave of FM and repeaters of that era kind of washed over me. However, I did pay some attention, and by the late '70s I found myself the frequency coordinator for northern Illinois, including the Chicago metro area. Sherman, set the Wayback for the early '60s. …

Frequency coordination and its close cousin, band planning for VHF/UHF FM, are two of the big success stories in amateur radio—our generation's version of crossing the Atlantic on HF. During the '60s there was just a little FM/repeater operation on ham radio, and before 1960 it pretty much didn't exist at all. I was licensed in 1965, and 2 meters was fairly quiet around Chicago. A bunch of us operated AM just above 145.0 MHz. There were a few big-gun weak-signal ops on SSB and CW, a moonbouncer or two, and maybe two repeaters that were a secret well kept from most of the ham community.

In the '60s the FCC changed some rules for commercial two-way radio users and put a lot of FM equipment on the surplus market, cheap. Hams, many of them two-way Techs, snapped them up, retuned them for ham frequencies, and started putting up repeaters.

We had a lot of totally vacant space on 2 meters, mostly between 146 and 148 MHz. The 30-MHz wide 70-cm band was almost completely empty. There was no band plan to tell the hams what frequencies to use for these FM rigs and the repeaters that followed them, but they needed some kind of organization, because the radios were crystal controlled, both transmit and receive, so no "tuning around" was possible. Frequency synthesizers were a decade away. This fixed-frequency use was a foreign concept to most hams, who equated it with CB, giving FM a bad rap from the beginning.

Several factors conspired to make 146.94 MHz the de facto nationwide "first channel." Tech class hams couldn't operate above 147 MHz. The old tube-type radios were being tuned down from commercial channels between 150 and 160 MHz, and some just barely made it down to the ham bands, so you wanted to pick the highest frequency you could. The radios were designed for 60-kHz wide channels, so 147 minus .06 is 146.94, or "Nine-four." An FM star was born.

In some places 94 was used for simplex, and in others it was a repeater output, setting the stage for the first FM "repeater wars." In these early days, with just a handful of operators and very limited equipment, some of our pioneers didn't see eye to eye on spectrum use. Around Chicago, 94 was used for simplex, and people got very upset when someone put up a 94 repeater in a distant southern suburb. There was some bad behavior. I should know. I participated.

A few other repeater output channels became popular; 146.88 and 146.76 MHz caught on. However, there was no standard offset for the input frequency. That meant that your FM mobile was useful at home, but not on the road. Most radios had two channels. A deluxe radio had four. You usually spent more money on crystals than on the radio itself. *Flexible* was not in the vocabulary.

By the early '70s, FM was becoming really popular, despite condescending glances down long noses from "traditional" hams, and without any commercial off-the-shelf radio equipment to speak of. It was going to need some organization. With a lot of help from *73 Magazine* (especially Bill Pasternack's "Looking West" column), and some from the ARRL, hams worked out a band plan calling for 60-kHz channel steps, going up and down the band from 146.94, with a 600-kHz repeater offset. Regional groups did most of the planning, with hams in Texas taking a leading role. I suppose the amazing thing is that we didn't end up with a bunch of incompatible, regional plans. The ARRL VHF Repeater Advisory Committee helped give the band plans nationwide stature. We do have some regional differences today, such as the 15- vs. 20-kHz channel steps on 2 meters, and some upside-down UHF repeaters in some parts of the country, but the consistency of the plans is more remarkable than the differences.

Frequency coordination was the next order of business, to keep repeaters with overlapping coverage from interfering with one another. Most areas developed repeater councils, or at least had an individual volunteer to be the coordinator. It was totally voluntary, and not always popular or successful. Some hams resisted being told what to do, and some coordinators wielded their authority with a heavy hand. FM/repeater pioneers were some of ham radio's most independent thinkers. They butted heads over the use of the few "popular" frequencies (the "repeater wars" I mentioned earlier) for a while, but eventually most caved in to the logic of how well things worked if we cooperated.

Manufacturers took notice and began to offer true "amateur radio" FM equipment. After some shakeout, the norm became 12-channel, 25-watt crystal-controlled radios from several Japanese and American manufactures, including Motorola, whose surplus commercial equipment had led the "conversion" wave (along with some GE, RCA, and Johnson stuff). Motorola, though, was late to the party, marketing a rather expensive 12-channel crystal rig while the others were introducing the first synthesized equipment in the mid- to late '70s. With more radios, and radios with more channels, repeater building and FM use boomed.

The band plans developed in those early days received some tinkering over time,

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Tone Revisited

If you're serious about repeaters, by now you've probably heard that SERA, the SouthEastern Repeater Association, rescinded their decision to require tone, both encode and decode, as a condition for coordination on all repeaters in its eight-state area. The decision was unanimous at the SERA board meeting last June, but it turned out that some of the directors who weren't able to attend the meeting were opposed to it. In addition, after taking a beating from both repeater owners and users, a majority of the directors decided to reconsider.

As I said in my Fall 2004 *CQ VHF* column, most of the SERA directors didn't intend to pass a blanket requirement for all repeaters to use tone, period (with a two-year grace period for existing repeaters). While the subject was being kicked around at the meeting, somebody asked if repeaters would be decoordinated if the owner decided to stay carrier access. The answer was no, and that satisfied the members at the meeting. However, it didn't get into the motion or the minutes of the meeting. It is in my notes, but that's not very official.

The SERA board kicked around other wording on its mailing list. A couple of SERA's directors tried to create motions that came closer to the spirit of what they thought they had passed. That proved more difficult than just rescinding the original vote, at least to quell the storm. I expect a lively winter board meeting this January, which will be history before this issue of *CQ VHF* reaches your hands, so watch QRZ.com and eham.net and maybe the SERA website (www.sera.org) for any late fury. If debate has been kindled in your area, let me know!

I think the merits and details of the multiple sides of the issue have been flogged to death (many of you are quite passionate about the issue—pro, con, and otherwise), but I received some mail from *CQ VHF* readers with some unique thoughts to consider.

Thoughts on Tone

Len Umina, WT6G, in Sacramento, California, uses a tone-flexible controller from Pacific Research to allow all tones, except the tones of his co-channel neighbors, to access his repeaters. He suggests setting up your controller so that it will respond to the "wrong" tone, or no tone at all, with an announcement of the tone you need to key up and yak away.

Alas, Len, my experience is that few good ideas that require repeater technicians to implement a feature or function ever see widespread adoption. "Universal" tone, LiTZ, and even common regional tone implementation are rare birds. However, I'm happy to pass along your idea. It doesn't need universal acceptance. It will work on repeaters one-by-one and help a little.

Len had a question for the manufacturers out there: Why design radios to respond to just one tone? The ability to program multiple decode tones could be quite useful.

I'll add my own questions: What's up with slow "tone scan" as the method of discovering an unknown tone? Why can't the tone frequency pop up more or less instantly, the way it does on a frequency counter, ready to use? The more I hear about tone troubles, the more I think that flexible but easy-to-use tone operation could be the "killer ap" feature that will sell radios.

Stan Podger, VE3DNR, from Ontario, Canada, likes the way tone permits him to pick and choose repeaters to key up when the band is open a bit and he can "DX" across Lake Ontario. If the local machine is quiet, he can reach beyond it for a conversation without keying it up and bothering the locals.

DXing repeaters is one of those things your father may have told you never to do. "Repeaters are for extending the coverage of mobiles," he might have warned. Okay, maybe it was your mother, but probably not. Anyway, there are some repeater gurus who are reaching for their keyboards right now to tell me that Stan is way off base in DXing repeaters. I say phooey. Why not DX a bit and have fun? Weren't you just complaining recently about how underutilized repeaters are these days? Of course, the local machine must be idle when you DX.

I'll throw some of my own cold water on the idea just to keep my official curmudgeon status and keep everyone guessing. The problem with this is that the guy who is most likely to take advantage of it is the same jerk who operates as if he owns the band and all the repeaters are his personal play toys. He has no regard for his fellow hams and cares not what havoc he wreaks. He has one of the bigger towers in town, at least a 150-watt amp, and if you're having fun, he's probably not (and vice-versa).

Stan, on the other hand, told me that he'd cease and desist his DX contact the moment someone begins using his local repeater. Maybe think of this as knowing the rules well enough to break one now and then. Knowledge and courtesy would permit this kind of operation. There are some repeater owners who are aware of this potential operation but oppose it, perhaps because they feel that knowledge and courtesy are in short supply. They are afraid of letting the genie out of the bottle.

as we followed the commercial practice of narrowing deviation and slicing the channels in half, from 60 to 30 to 15 kHz, to accommodate more and more repeaters. Fifteen-kHz step use faced a technical problem, since standard "narrowband" 5-kHz deviation actually uses about 16 kHz of spectrum so there's some guaranteed adjacent channel interference. A strong adjacent channel signal will spatter in your receiver, causing annoying "grunge." For a while, some repeater councils recommended putting the new repeaters on the 15-kHz "splinter" channels upside-down, figuring that having a 146.94 repeater output next to a 146.955 repeater input, with significant geographic separation (50 miles or so), would at least give each repeater a fixed, predictable signal to deal with, and users would be faced with intermittent, weaker, and distant user signals adjacent to their receivers rather than a constant, strong repeater signal. However, other repeater councils didn't buy it and coordinated the new splinter channels in the usual configuration that had developed—minus offsets below 147 MHz and plus offsets above. That left repeater *outputs* in one state on the repeater *input* frequencies of machines in a neighbor state—a big problem, especially during a band opening. The upside-down plan was quickly abandoned, and repeater users were left to fend for themselves among repeaters on channels that were just a little too close together. Coordinators kept those repeaters about 50 miles apart, and that limited the problem to tolerable levels. Most repeater operators today probably don't notice.

The FCC also tinkered with the rules, reacting to repeaters' threats to take over the whole 2-meter band by prohibiting them below 146 MHz in the early '70s, and then opening up 145.5 to 146.5 again as FM operation dominated the band. At that time, Techs, who had privileges only from 145–147 MHz, were given the whole band, allowing them onto what were previously "General Class Snob" repeaters. Well, some people called them that.

In that "new" repeater spectrum, the councils sought to avoid the 15-kHz channel problem and made the channel steps 20 kHz. Repeater councils in some states, mostly in the west (plus Michigan and Alabama), decided they liked 20 kHz so much they switched the upper half of the band to 20 kHz, too.

The repeater boom continued through

the '80s. Radios became more sophisticated, but repeaters still mostly were built from surplus commercial equipment a decade or more old. In the larger metro areas 2 meters filled up. There were no more "band-plan" repeater frequencies available. A few hams went outside the plan and put repeaters on simplex channels, with non-standard spacing, or they used band-plan channels but didn't get coordination. I'll address these problems more in Part 2.

The '90s saw the introduction of the code-free Tech, and another boom in licensing and repeater use. That boom peaked in the middle of the decade, and some have seen a slow decline in activity since then. The number of repeaters continues to climb, with saturated 2 meters leveling off and the 70-cm band catching up. 220 (222 for you literalists) has lots of repeaters, but still lacks activity.

Taken for Granted? That brings us up to the present. Still today there are some conflicts and disagreements about coordination and the band plans, but it's all held up remarkably well over the decades . . . well enough for FM to be taken for granted—the Utility Mode.

Two groups that do not take them for granted are repeater owners and frequency coordinators. The coordinators deal with the reality of the band plans every day. Repeater owners don't think about it as much, but they become acutely aware of coordination and band plans when they want to put up a new machine or make significant changes to their current one.

What are the problems and challenges that we still face? I'll explore them in future columns. What do *you* think they are? Drop me a line. Also, if you were around in the early days, you might have a story or two to share about how we got where we are today.

APRS/Monitoring on the Road

Many hams have lamented the lack of simplex activity, especially among hams on the road traveling cross-country. I've had some luck making contacts on 146.52, but it's rare.

Here's an idea that might help you make a few more mobile contacts. It comes from Bob Bruninga, WB4APR, inventor of the APRS packet locating system:

> If you're on a long trip and between satellite passes and can't find anyone to talk to, just activate your mobile HAM "radar" detector. Many APRS mobiles run what is called "voice alert" on 144.39 MHz. This means they are *listening* with CTCSS 100. Thus, they never hear any packets unless someone is within *simplex* range of them and calls with CTCSS-100.
>
> It's like a radar detector. If you pass within simplex range of someone else with Voice Alert, even if he (or she) is not talking, you will hear an occasional ping because the APRS packet is also transmitted with CTCSS-100 (136.5 Europe).
>
> Even if you don't run APRS, but just want to see if anyone is in simplex range while driving, anyone can tune there and listen. If you hear a packet break your CTCSS 100 squelch, then you know someone is in simplex range and listening on the speaker for a call with PL 100.
>
> This is better than 146.52 because of the automatic "pings" by each such mobile. You can drive all day listening to 52 and pass within range of dozens of others, but if no one calls CQ once every two minutes or so, you may never find one another. (Two cars passing at 60 mph are beyond mobile range in 5 minutes. Also, statistically on the interstate you will pass by another ham about four to six times an hour.)
>
> With APRS Voice Alert you have four potential QSO guarantees:
>
> 1. One of the other operator's radios is *always on*.
> 2. One of his radios is *always* tuned to 144.39.
> 3. If he has set Voice Alert, then he has the *volume up* and will hear you if you set CTCSS-100.
> 4. If you monitor with CTCSS-100, you will be alerted by his packets when he is in simplex range of you.
>
> However, if you call on 144.39 Voice Alert, you *must* state "calling on Voice Alert." Otherwise, he will assume your voice came in on his normal voice radio and he will come back to you there, because he has no way of knowing otherwise.
>
> Note also that you must set CTCSS 100, or you will be driven crazy by all the packets. Remember, Voice Alert is *only a CALLING channel*. You must immediately QSY to a voice channel for a QSO. 144.39 is a packet channel only. This Voice Alert process is only a convenience for contacting mobile operators.
>
> **Note:** Never set PL 100 from a fixed APRS station. No one wants to hear your pings unless you are sitting there *actively* looking for a QSO. In a mobile, if the APRS rig is on, he is there and his volume is up and he is listening. Thus, Voice Alert is considered to be a "live" process only.

KN4AQ here again. I don't know how active this Voice Alert system is. When I boot up APRS in this area, I see few mobile trackers running around. However, like any neat idea it will grow if people give it a chance. Let me know if you try it.

BPL Update

Most of you know I've been keeping my finger on the pulse of BPL (Broadband over Power Lines), a pulse that's been beating a bit stronger after the FCC removed some of the "regulatory uncertainty" with last October's Report and Order. Although Progress Energy ended its trial with no immediate plans for the future here in North Carolina, trials and full rollouts are spreading across the country.

The vendors' and utilities' new mantra is "We've solved the interference problem." They claim that hams are not complaining. While it's true that hams are not complaining in large numbers, it's because large numbers of hams are not yet affected by BPL. However, hams are complaining in small numbers, and the complaints are being misunderstood, if not completely ignored.

All the vendors are trying some form of notching our bands as their signals cross our frequencies. They're calling that good enough, but so far no system gets a clean bill from the ARRL's chief BPL investigator, Ed Hare, W1RFI.

I spent a few days with Ed this past December, and we toured the Briarcliff Manor, New York BPL system. We ran into an Ambient engineer who told us he thought the system had been pretty well cleaned up. He was earnest about wanting to make things work. However, our quick drive through the neighborhood showed he had a long way to go.

We parked under one line and tuned across 20 meters. The BPL signals were over S-9 and covered up many of the signals on the band. I asked Ed if this band was notched, and he said it didn't sound like it. Then he tuned outside the band, and the signals came up to S-9+20. The band *was* notched, but the notch was ineffective. Then we drove down the road, listening to the county hunter net on 14.336. It was obliterated for several minutes as Ed ran the length of the line at the posted speed limit. As a result of this observation, the ARRL has repeated its request that this system be shut down.

I've seen notching that worked better, but I haven't seen any that would solve the interference problem for a home station within a block or two of a power line. Those stations would get

S-5 or better BPL signals, if there were any. Right now there just aren't many active hams that close to power lines in BPL areas . . . but there will be.

The utilities and vendors aren't putting two and two together. Those that genuinely want to work with hams and avoid interference desperately want to believe that they are solving the problems with their notches. Others, more disingenuous, just beat their PR drum that the problem is solved (the problem they denied existed earlier last year).

There are two more show stoppers: mobile hams and all SWLs.

Mobile hams led the way in BPL investigation, since there still are few hams living in BPL areas. Utilities, including my own Progress Energy, have characterized this as hams just looking for trouble, and the FCC bought into it in its investigation here last summer. Mobiles can just drive through it, they say. They missed the point. Yes, we went "looking for trouble." We went in to see what the BPL would sound like if there were any fixed stations, and we found it. We told the power companies. We also filed the complaints with the FCC, because the BPL industry was claiming there were no complaints, hence no interference, and some utilities took offense. To be honest, many hams have also taken great offense, and spared little language in saying so. If the utilities were smart, they would look at our evidence and recognize the potential problem waiting in a general rollout. I suspect some of the engineers see it, even if the managers and spin doctors don't.

The best notching I've seen so far makes a fairly acceptable situation for a mobile driving by a power line using a notched ham band. Not all the notching meets that standard, and the best notch still isn't good enough for a home station near the line. They need another 20 to 30 dB, and the technology isn't producing that yet.

So far, too, none of the systems has paid one iota of attention to SWLs. The international shortwave broadcast bands have not been notched anywhere. SWLs have complained individually and as a group and have been ignored so far. I know if my local utility changes course and implements BPL in my neighborhood, and it somehow notches the ham bands to my satisfaction, I'll next look at the SW broadcast bands. If I find BPL there, I'll complain (again). SWLs go mobile, too. Notch all that spectrum, and all that the new Part 15 requires, and is there enough left for BPL throughput?

Ingress Tests

Hams are also starting to pay more attention to "ingress" problems—ham signals disrupting BPL operation. Ed Hare is collecting data, and more tests are confirming that it's a problem, especially for the Main Net systems. I performed a brief test on the Emmaus, Pennsylvania system, an older Main Net system operated by PPL. PPL had a BPL demo set up in a storefront, and while I played with the computer, Steve Dove, W3EEE, parked under the power line a half-block away and keyed his 20-meter mobile with a 50-watt carrier. The video I was streaming (the FCC Open Meeting in October, where the Part 15 revision Report and Order was approved [I enjoyed the irony]) ate up its buffer and froze. It never recovered even after Steve let go. Carriers as low as 5 watts prevented me from opening new web pages, and it took about a minute to see progress after he dropped off. We didn't try SSB, or other bands or modes, as our time was limited. However, it pointed to the need for more thorough testing. This system, by the way, has no notches for the ham bands and sprays S9+ RF between 5 and 22 MHz over half the town. You can't "drive out of it" without leaving the large neighborhood.

BPL systems are designed to ignore interference on any spot frequency. They have tons of interference on the power line itself. A ham taking up a few kilohertz of a BPL block that's 15 MHz wide, as the Main Net system is, doesn't cause any damage, but a really strong ham signal might completely overload amplifiers and knock out service for as many homes as that amplifier feeds. Also, while we're on solid ground with Part 15 (the unlicensed devices must accept any interference they get from licensed services—that's us), that has always been a hard sell in neighborhoods. The more alarmed hams worry that one day BPL will be so big and important that it will gain official protection from the FCC. It's hard to believe that a huge communications infrastructure would be built on the flimsy framework of Part 15, but that's what's happening.

The next step for hams and BPL? Be vigilant. Know your spectrum. Learn what the flavors of BPL sound like. Keep an eye on the local paper to see if your utility announces plans or tests. Each city should form a "BPL Committee" with members who gain expertise in listening for BPL and writing complaints so that when we do complain, we're sure it's BPL and not one of the many other whirrs and bleeps our spectrum is heir to. Work with the local utility if it is cooperative, but be wary of pledges of cooperation that it can't fulfill.

That's it for this time. See you in the spring, and don't forget to send me your "coordination" experiences.

73, Gary, KN4AQ

CQ's 6 Meter and Satellite WAZ Awards

(As of December 1, 2004)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones Needed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25,28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,7,10,12,18,19,23,24,26,29,31,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23.24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37, 39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. Last year we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

**17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>*

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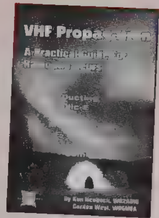

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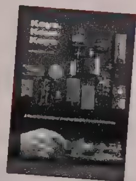

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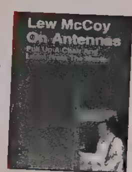

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By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

A Universal Antenna

I'm about to do something I really hate to do, but it's been a very hectic month as I write this in late December in a motel in Fordyce, Arkansas. I'm going to write about an antenna I have not had a chance to prototype. It is, however, a pretty low-risk project.

RadioShack sells a "Universal Antenna" (catalog No. 17-345; photo A) for analog, TDMA, CDMA, and GSM cell phones, with even an implied reference for using it with 915-MHz spread-spectrum phones. That's a pretty big range of frequencies.

I purchased two and split open the first one before I even left the store's parking lot. A circle and a rectangle? I'd never seen anything like this and could hardly wait to get it home and fire up the network analyzer.

In photo B you can see the SWR is less than 2 to 1 from just under 800 MHz to 2000 MHz. I didn't take a photo of my later sweeps, but it kept that same pattern of humps just under 2 to 1 SWR up to over 6000 MHz. That's a pretty big range of frequencies!

Scaling up the 3-inch diameter disk to a 17-inch disk would bring it down to 140 MHz. What a construction project!An antenna that would work on 146, 222, 440, 900, and 1290 MHz (figure 1)! Then throw in the VHF, UHF low, and UHF high scanner bands as well. Don't be afraid to use something bigger than 17 inches in diameter. It's not a particularly critical dimension as long as it's at least 17 inches across. Five ham bands in one antenna is a pretty versatile antenna.

Note how the coax is run down the center of the rectangular element (photo C). That coax routing down the center was very important for a broad frequency response.

Construction

Of course I haven't built one of these Universal Antennas as yet, but I'm thinking about a trip to the Dollar Store for a pizza pan and a cookie sheet, or maybe a big sheet of aluminum-foil-covered styrofoam, house insulation siding, and solder tabs as we used for the patch antennas we covered here last summer. I look forward to what readers come up with, too.

A sheet of metal can be radar simulated with just a wire frame of the edges of the sheet metal. Maybe we can get simi-

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e-mail: <wa5vjb@cq-vhf.com>

Photo A. The Universal Antenna.

Photo B. Network-analyzer plot from 0 to 2000 MHz.

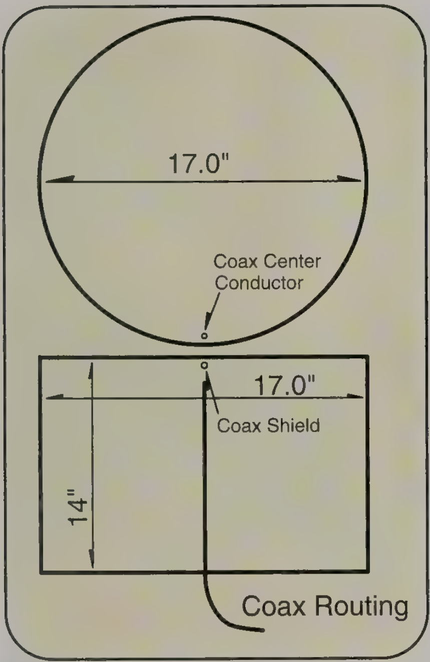

Figure 1. The Universal Antenna for146, 222, 440, 915, and 1290 MHz.

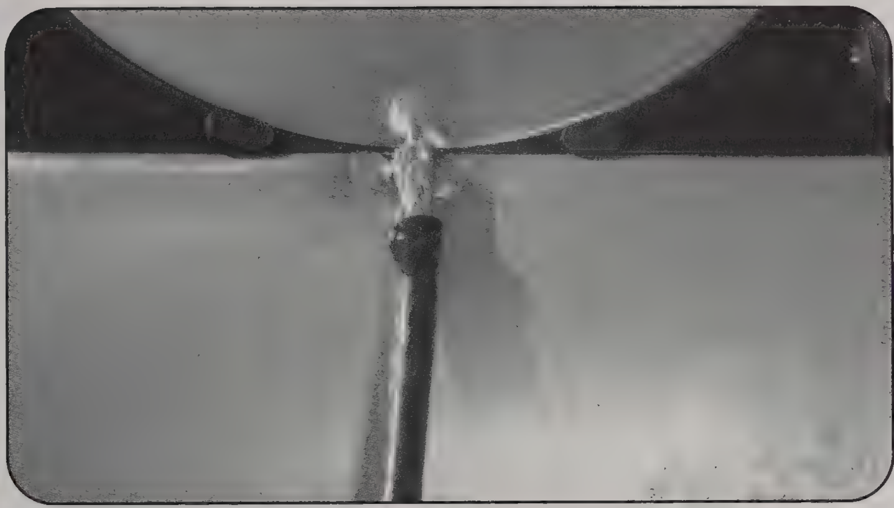

Photo C. Universal Antenna coax attachment points.

lar results with just a loop and square made of out copper wire. That sounds like still another construction project.

Letters, We Get Letters

From John in 4-land we have a request to publish a 2.4-GHz version of the Cheap Yagi. While I have designed versions etched on PC board going up to 5.8 GHz, 1.3 GHz is the highest frequency I have gone up to for a wood-and-wire version of the Cheap Yagi. Hmmm . . . popsicle sticks, #14 wire, and a little hot-melt glue?I'll see what I can come up with.

From Paulo in Brazil, I received several photos of his Cheap Yagi using aluminum elements. Instead of soldering the coax directly to the driven element, Paulo made clips out of brass stock (figure 2), clamped those to the elements, and then soldered the coax to the clips. I personally prefer to solder the coax to the driven element—a good, solid connection with no place for corrosion to grow in the joint—but if you have a lot of aluminum tubing, it's a valid way to build the antenna.

The best report came from a chap who works for one of those federal agencies with three letters. It seems he was sent to a monitoring station in Pakistan just along the Afghan border. Osama's boys were using off-the-shelf amateur handhelds to talk to one another. I guess the Afghan version of our FCC hasn't been doing their job lately. Anyway, the signals were just detectable with the monitoring station's discone antennas. Thus, he built a 2-meter and a 440-MHz Cheap Yagi "literally out of broom sticks and coat hangers" and connected them to their monitoring equipment. He says the signals were good and the information . . . well, useful. That certainly is my most interesting reader endorsement.

Some of my best ideas for articles come from you, our readers, so keep those antenna questions and ideas coming.

73, Kent, WA5VJB

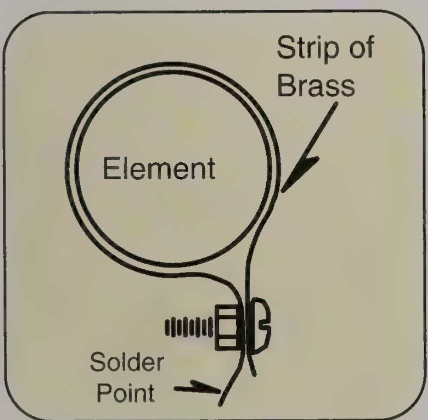

Figure 2. Element clips for the aluminum driven elements.

By Chuck Houghton,* WB6IGP

MICROWAVE

Above and Beyond, 1296 MHz and Up

The Qualcomm "Omnitrack" DRO Synthesizer

The Qualcomm DRO (dielectric resonant oscillator) synthesizer normally operates on a frequency of 2620 MHz and has an output power of +10 dBm. Frequency stability is under control of a dielectric resonant controlled oscillator (DRO). This ceramic puck stabilizes the oscillator, and synthesizer phase-locked-loop (PLL) circuitry must be modified to change the output to another frequency more desirable for amateur microwave use.

Unfortunately, the DRO synthesizer is controlled by its divide-by reference of 1.25 MHz (random-access [RA] counter set to divide reference 10 MHz by 8). A solution was to change the RA counter to divide the stock frequency of 10 MHz by 64 for a new reference frequency of 156.25 kHz. There are many possibilities, but for this application the irregular frequency steps limited those frequencies that could be reached by the PLL chip. Modification of the DRO took the form of adding solder—bits of copper or short lengths of copper wire soldered to the top of the DRO, stretching the DRO resonance. This could be a small coupled pF capacitor, or an inductance used to tweak the DRO to a new frequency (free-running frequency near desired operation point).

The above is where this project lay for some years. Then while cleaning out the shed and trying to reorganize material stored there, I came upon a large box of DRO synthesizers. At the same time, I revisited the file of material and modification notes that John Stevens, WB2BYP, and I had worked on previously. I had done the original modification work using the stock reference frequencies of 1.25 MHz and 156.25 kHz, but John saw a much better use for these DRO synthesizers, working his plan around a new reference frequency of 1 MHz. This allowed many other possible frequency combinations that were capable of being reached by reprogramming the PLL dividers and constructing a new divider (divide by 10) to produce a 1-MHz reference from the 10-MHz TCXO (temperature-compensated crystal oscillator).

John put together a great modification procedure and gave me his permission to cover it here. I am sure it will be met with great interest, especially because the synthesizer PC boards are still available from the author (WB6IGP) for modification to other useful microwave frequencies.

Modification for 2592 MHz

The sequence of images and comments builds upon my article entitled "Above and Beyond," which appeared in the June 1994 issue of *73 Magazine*. I had known about these synthesizers for a few years, and only recently started thinking about

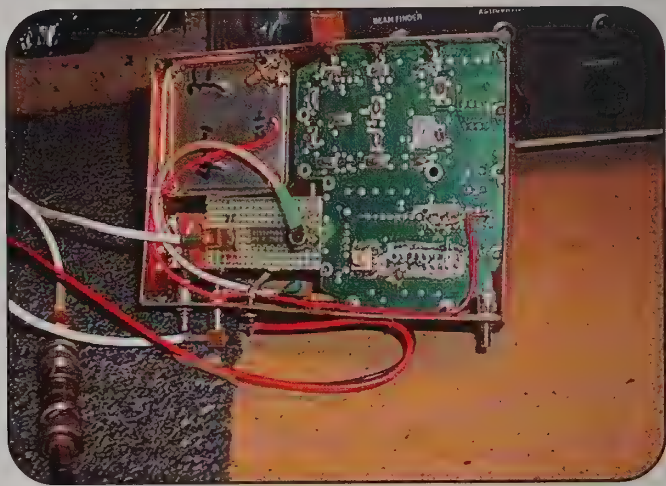

Photo A. Bottom of the synthesizer PC board with pins of the synthesizer chip isolated by dremel-cutting around each pin to isolate them for experiments on other frequencies.

them as an LO (local oscillator) or marker generator for microwave experimentation. I had been looking for a signal source that I could lock to a 10-MHz TCXO for field use or as a GPS-disciplined oscillator. I wanted to know with some accuracy where the band edges are at 10368 and 24192 MHz. Jud, K2CBA, uses one of these as the basis for an LO in his homebrew 10-GHz transverter. The frequencies at which the synthesizers lock with the Omnitrac 10-MHz TCXO are limited in utility, but if you are open-minded about what to use as an IF and have a rig that will do it, you can use the boards with minor mods.

In my *73 Magazine* article I discussed some of the frequencies that are available with a minimum number of modifications, and I provided some good schematic information. Note that you may have to do some drawing out of the circuit to satisfy your curiosity regarding some of the board's finer detail, such as the reference filter and VCO (voltage-controlled oscillator). One of the boards I modified had some workmanship errors that contributed to a failure in the supply voltage to the VCO buffer amp. It was an easy fix, however, and the unmodified board came up with +10 dBm at 2620 MHz. Jud and I discussed the utility of the boards during some Monday evening 2-meter chats, and a couple of ideas came to mind. A few evenings spent at the test bench led to some interesting findings. I wanted the lock-to frequencies to come out in more convenient values for common IFs with low side injection.

What followed is the Qualcomm synthesizer with modifications to place it on 2592.000 MHz (10368.000 divided by 4). I am using this for a marker generator. The reference is running

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Photo B. Top of the synthesizer showing added perf-board transistor amp and 10-MHz TCXO used to provide clock input to the synthesizer via a new, added 7490-divide-by-10 chip.

at 1 MHz, and the *R* divider is set to 8. That gives an internal reference frequency of 0.125 MHz. The advantage of this is the lock-up points now occur at more convenient frequencies in the 2.5-GHz region. The existing scheme divides the 10-MHz reference oscillator by 8 to yield 1.25-MHz reference steps, yet the lock-up frequencies are less useful. By dividing the reference oscillator by 10 using a 7490 decade counter, and giving the chip 1 MHz instead of 10 MHz, the 0.125-MHz reference step is achieved without changing to a different external TCXO. You have to by-pass the on-board reference frequency filter to introduce the 1-MHz signal from the decade divider. The great thing about this is that the LO or marker generator can be run from an inexpensive 10-MHz TXCO for better stability than open-air or heated-crystal oscillators.

For 2592 MHz the *N* counter has to be set to 80, and the *A* counter has to be set to 16. I dremel-tooled the board to isolate all the *A* and *N* counter pins on the MC145152 (see photo A for the bottom of the PC board). This was more work than needed, but it allowed me to play with programming different frequencies. I put a $^1/_4$-inch lead of #22 wire on the DRO to add some parasitic inductance to achieve lock. Note that there is a "slice-to-tune" element on the existing PC board that can be played with to yield a more convenient open-loop oscillation frequency. Output is about +10 dBm. I did not bring in the loop filter to limit the phase noise, as I was looking for an ultimate accuracy signal source, more so than an LO. If it were used as an LO, you would want to add capacitance to the loop filter to reduce receive reciprocal mixing noise from nearby stations due to oscillator phase noise. The existing amount of capacitance will have to be increased by a factor of about 10.

I added the lock indicator to help diagnose lock conditions. I think this really is a big help, and it is right there and easy to do. It just takes an LED hanging off one of the pins on the white pin header. Note that it is dark when open loop, dim when unlocked, and bright when locked. This is an inexpensive, useful feedback. The modified synthesizer will hit all common LO frequencies for amateur bands, as well as the in-band signal. For example, it can be made to hit 10224/4 as well as 10368/4. It also will hit the band and LO frequency squarely at 24192. It will hit an 18th sub-multiple of 47088 MHz, as well as the

Photo C. The modified synthesizer operating at 2688 MHz on John, WB2BYP's workbench with a spreadsheet in the background for programming the synthesizer.

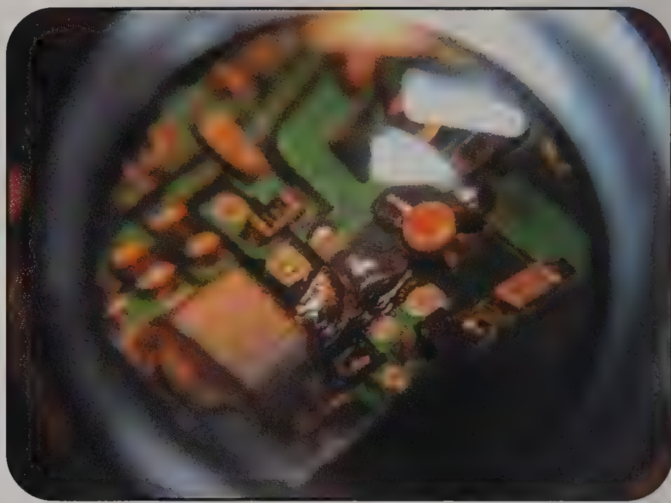

Photo D. Modification of DRO synthesizer by adding a drop of solder to the DRO ceramic element to change resonance to a frequency other than the stock 2620 MHz.

frequency 144 MHz below that. If you are using a DB6NT mixer that runs LO at half or quarter frequency, you can find these frequencies, too.

Note that the frequency to hit the 18th sub-multiple of 47088 is easily within the range of the unmodified DRO. Keeping the DRO is advantageous, as it is fairly high Q. To hit the other frequencies you will have to substitute an L/C combination with a tiny Johanson trimmer or equivalent and resonate close to the intended frequency. I know this works between 2 and 2.5 GHz, although I have not pushed it up to 3 GHz yet. More to follow.

What is needed to simplify the process is a simple map that says, "Ground these pins to get these frequencies." (The program.pdf document is provided with the synthesizer.) It's from an Excel sheet that John developed to calculate the combinations of programming the pin-for-pin synthesizer chip vs. frequency obtained. The synthesizer board is on the right, the 7490 is pasted onto the perf board, and the TCXO is on the lower left (see photo B for details of the top of the modified synthesizer with added transistor amp and TCXO 10-MHz oscillator). There is a 2N5179 buffer amp to build up voltage to the TTL IC. It would be better if there were a CMOS IC as the decade counter. The TTL 7490 was what I had at first. This is running off the GPS-disciplined oscillator in the photo. The ultimate accuracy at a reasonable cost can be had by using a GPS-disciplined 10-MHz oscillator for one part in 10 to the minus 12 accuracy. Translated to 10368 MHz, the accuracy is pretty darn good in comparison to homebrew, DEM, or DB6NT LOs. The stability is as good as you feed it.

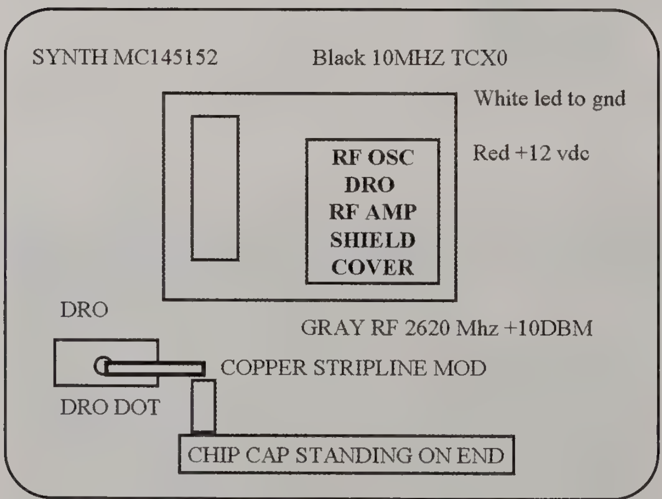

Figure 1. Connections for the test on 2620 MHz to verify the synthesizer works as a stock programmed unit. Also shown are details of the copper stripline added between the DRO center dot and the transistor to obtain a free-running frequency slightly above the desired frequency before programming the synthesizer.

Modification for 2688 MHz

Here is the second unit, modified for 2688 MHz. This frequency is 24192/9 and is useful as a signal source. This is done by setting N to 83 and A to 16, and driving the reference divider with 1 MHz. In this case I am sourcing the 1 MHz from the other synthesizer, running from the 10-MHz TCXO/decade divider. See photo C for this modified synthesizer on my workbench.

This is the modification to the DRO in order to get it to go significantly higher in frequency (see photo D). The DRO is the big block at about 8 o'clock in this crude view through an eye loupe. The VCO transistor is the device about in the center. This mod was accomplished by lifting the coupling chip capacitor into the air and putting a solder bead over the pad with the transistor. I removed the pad below the DRO connection and put a large bead on the DRO center pad. The chip capacitor now bridges the two low-inductance solder beads. With this technique I was able to get the free-run frequency up to 2718 MHz. This made the oscillator easy to pull in to 2688 with tuning voltage.

It is good to know that the DRO can be pushed this far in frequency, because there are a lot of useful frequencies if the oscillator can be made to lock above the design center of 2620 MHz. A signal source at 47088/27 = 2616 MHz is possible without

mods to the DRO, and if the DRO can be pushed to 2816, a signal source for 76032 can be made. Lots of LO possibilities exist. However, for the most part they will require some creative mods to the DRO or the removal of the DRO, replacing it with a Johanson trimmer of small pF value and a strip of tweaked-to-frequency copper or a coil for lower frequencies. The oscillator should be made to free run about 20 MHz above the operating frequency to have a suitable lock voltage. The DRO is easy to remove by disconnecting the solder connection and heating up the body. This modification procedure by John, WB2BYP, can be found on the web at <http://www.storyavenue.com/qualcomm.htm> with John's conversion data and more details of the Qualcomm DRO synthesizer.

Applications

While the DRO synthesizer does have limitations, John has greatly improved the adaptability in his conversion by changing to a more useful reference frequency. I have done lots of different applications sticking with the 1.25-MHz reference frequency and its limited operation. For instance, we were able to use this synthesizer on our 47-GHz transceiver. We cut one pin open (TTL high) and grounded two other pins (TTL low) on the synthesizer chip, allowing operation on 2640 MHz. The idea was to use a Verticom very-high-quality BCD (binary coded decimal) controlled agile synthesizer operating at 10.44250 MHz. This LO drove a PECOM TX Module (multiply by 2 = 20.885 GHz + the LO drive to the IF port at 2.640 GHz for a output at 23.525 GHz). Doubling in frequency in our final harmonic mixer produced 47.05 GHz. Using an IF of 145 MHz produced 47.195 GHz. While the rig is not a barnburner, it has shown to be a reliable and simple rig to put together. Of course, the use of the MTS2000 Verticom synthesizer, the step frequency of which is 1 kHz from 8.7 GHz to 10.7 GHz, was a key element in making the system's main local oscillator easy to use.

The system's IF drive LO: The DRO synthesizer also proved quite versatile in its easy conversion to 2640 MHz because the stock synthesizer frequency steps are at 20 MHz, making its use in this application a no-brainer. I thought I would try to get the DRO oscillator to free run (no lock) somewhere in the 2592 frequency band. Remember, this is 2592 times 4, which equals 10368 MHz, a great test shot to demonstrate what I had to do to get there at this frequency of 2592 MHz.

First I removed the chip capacitor from the DRO center dot and the transistor on the PC board. Then, using a solder sucker, I removed the excessive solder from the DRO center connection to the PC board trace to leave the DRO center dot floating (isolated). I re-attached the chip capacitor standing up on the transistor side of the now open PC board trace and soldered it to this PC board trace. I fabricated a small section of copper tape that was a few thousands of an inch thick and soldered one end of it to the DRO center dot. I soldered the other end to the chip capacitor (top) while it was standing on end, thus inserting a new inductance coupled by the series chip capacitor between the transistor and the DRO center dot. As I write this, a half-hour has gone by and the frequency of the free-running oscillator is still 2593.73 MHz as read on my frequency counter. Not bad for free running!

The first frequency I came up with was 2400 MHz, while the oscillator was free running. That meant my copper inductance was too large. Changing the copper inductor (a short piece of copper tape about 3/16 by 1/4 inch was use for first trial) by removing some length and width a bit at a time brought the free-running oscillator up to 2593.73 MHz. During the process of soldering and unsoldering, the chip capacitor got lost when it went flying from the tool that held it. I replaced it with a 1.1-pF chip capacitor (not a surface-mount standard type, but a microwave type from ATC [American technical Ceramics], .050-size 1.1-pF chip capacitor to reach the 2592-MHz range). I found I could go down to approximately 2100 MHz by replacing the 1-pF chip capacitor with one in the 5-pF range.

The bottom line is first adjust the chip capacitor or change the dimensions of the copper stripline inductance to achieve a frequency close to the one in which you are interested. Then set the synthesizer chip pin for pin programming to achieve synthesizer lock. For an LED indicator, tie the white wire to one side of the LED and ground the other. If you want to go up in frequency, take some copper off the copper bit; to go down in frequency, add a small bit of copper to the stripline trace, making line dimensions larger.

Check out the synthesizer first by connecting a crystal 10-MHz source to the black-shielded lead, +12 volts to the red lead, and the LED to the white lead. The synthesizer should fire up and lock on 2620 MHz. If the LED is not on, reverse the connections to the LED—no lock LED off; lock okay LED bright (see figure 1). For connection power lock and RF input output wiring.

The configure the 7490 for dividing by 10, the pinout configuration is: 10-MHz input pin is 1; tie pin 11 to pin 14; ground pins 2, 3, 6, 7, 10; positive VDC on pin 5; and 1 MHz output on pin 12.

Summary

The synthesizers are available from me, WB6IGP. Two DRO synthesizers are $22 postpaid, U.S. dollars. The synthesizer requires a 10-MHz crystal source, which is not supplied in this package. Normally, a 10-MHz TCXO is used for this function. I provide some schematic detail and a copy of the programming spreadsheet that John developed, plus some other conversion details that were too numerous to include in this column. I will be happy to answer questions related to the synthesizer or other microwave-related queries. Please e-mail me at clhough@pacbell.net for a quick response.

In closing, I would like to thank John Stevens, WB2BYP, allowing us to publish his modification procedure and conversion data in this column.

73, Chuck, WB6IGP

By Tomas Hood,* NW7US/AAAØWA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

More on Sporadic-*E*

During the beginning of November 2004, a series of solar-flare eruptions occurred originating from a large and moderately complex sunspot group, NOAA Region 696. Solar-flare activity starting with the November 5th long-duration M-class flare resulted in a series of Earth-directed coronal mass ejections (CMEs) that impacted Earth's geomagnetic field with severe (G4) geomagnetic storms. On November 7th a large flare eruption on the Sun triggered a moderate to strong solar-radiation storm. The CME activity produced periods of strong geomagnetic storms starting on November 7th, but peaking on November 8th and 10th.

Solar-radiation storms cause an increase in proton bombardment of the Earth. One result of November's geomagnetic storms and proton events was the extraordinary display of the aurora both in the Northern and Southern Hemispheres. Observers of the visual light show reported seeing the aurora as far south as Alabama in the Northern Hemisphere and as far north as New Zealand in the Southern Hemisphere.

The plots shown in figures 1 and 2 show a comparison of normal solar activity in October 2004 versus the activity during the geomagnetic storm during November. The difference is dramatic. In particular, note the large increase in highest-level (green) proton flux on November 10th. The increase in these particles rarely rises above the 0.1 (first) level on this plot.

Solar Region 696 continued to produce flares, as high as an X2.5-class flare on November 10th. These were accompanied by CMEs that continued to provide fuel for aurora and even sporadic-*E* (*Es*). A surprise, since *Es* is not typical during November, it was speculated that the ionosphere was loaded with electrons, causing a sudden and extremely rare November 144 *Es* opening. European VHF operators reported that while

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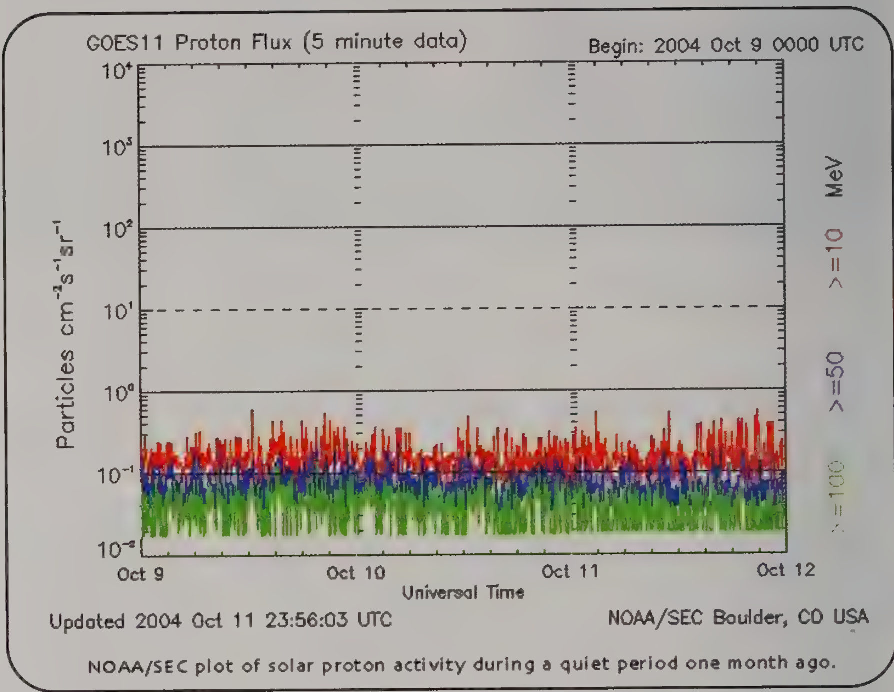

Figure 1. Normal solar activity during October 2004.

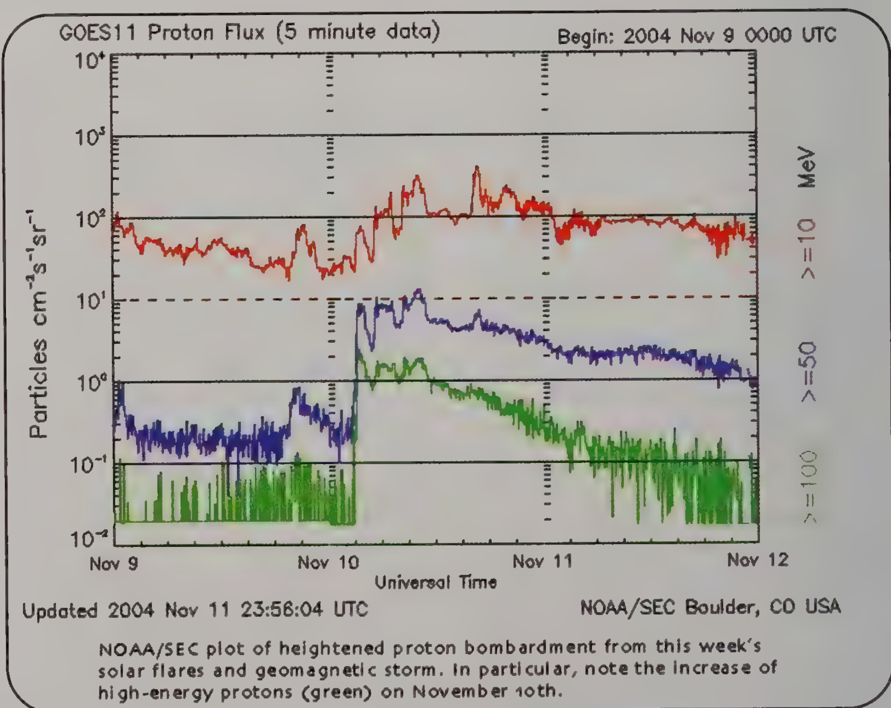

Figure 2. Activity during the geomagnetic storm of November 2004.

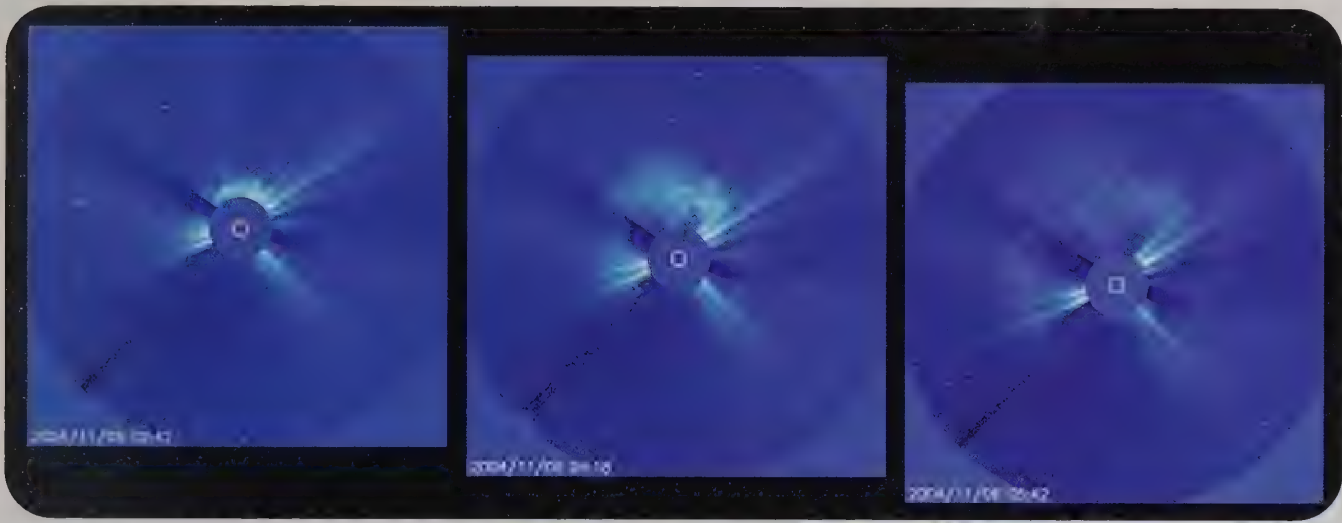

Figure 3. The LASCO instrument on the Solar and Heliospheric Observatory (SOHO) gives the best view of the wispy halo CME blowing out into space. LASCO observes the solar corona, the outer atmosphere where all the storms transpire, by blocking out the Sun like an eclipse. The small circle in the center of the image is the Sun. (NASA/ESA image)

there was still aurora in the north, clear, unmistakable *Es* conditions occurred in southern Europe.

Figure 3 shows the "halo" coronal mass ejection of November 6th. A *halo* CME is so named when a CME is directed toward or away from the Earth and is seen as an expanding circle of particles all around the Sun. When we see a halo CME heading toward Earth, we can expect a sure disturbance of the geomagnetic field around the Earth.

Research scientists have discovered that during the course of the 11-year solar cycle, the Sun actually reverses its magnetic poles. This flipping happens each cycle, with the north and south poles of the Sun violently switching places near the solar-cycle maximum. The next reversal is expected to occur possibly in 2012.

By studying the vast amount of raw data gathered by Solar and Heliospheric Observatory (SOHO) spacecraft, scientists have discovered the process by which this reversal may be accomplished. The data has revealed that CMEs play a major role in the Sun's magnetic-pole swapping. This flipping is the cumulative effect of more than a thousand of these huge eruptions which blast billions of tons of electrified gas into space. These CMEs carry the Sun's old magnetic field away, allowing a new one with a flipped orientation to form.

It has been determined that it takes more than a thousand CMEs, each carrying billions of tons of plasma from the Sun's polar regions, to clear away the old magnetism. Finally, when all of the old magnetism is thrown away, the Sun's magnetic-field lines run in the opposite direction.

This is the source of the recent occurrences of intense geomagnetic storms, such as the one in July 2004. These flare-ups come out of some very quiet periods, but they are normal. This is a sign that the Sun is continuing to get rid of the current complex magnetic structures as it starts to form new ones with the reversed orientation.

Since the Sun's magnetic field permeates the entire solar system, and beyond (in a region called the *heliosphere*), it interacts with the Earth and the Earth's magnetic field (a field known as the *magnetosphere*). The Sun's huge magnetic field is called the *interplanetary magnetic field* (*IMF*) and is a primary cause of space weather. Sprawling out away from the Sun is a solar wind that rides the IMF.

As Earth orbits the Sun, it dips in and out of the wavy current sheet of the IMF. On one side, the Sun's magnetic field points north, or toward the Sun. On the other side, it points south, or away from the Sun. The IMF's orientation is indicated by the B_z index. When the B_z is negative, it indicates a southerly-orientated IMF; when positive, it indicates a northerly-oriented IMF.

South-pointing solar magnetic fields tend to "magnetically reconnect" with Earth's own magnetic field. This allows the solar wind, and the plasma, to flow in and collect in a reservoir known as the *boundary layer*. The energetic particles riding the solar wind can then penetrate the atmosphere, causing aurora and triggering geomagnetic storms.

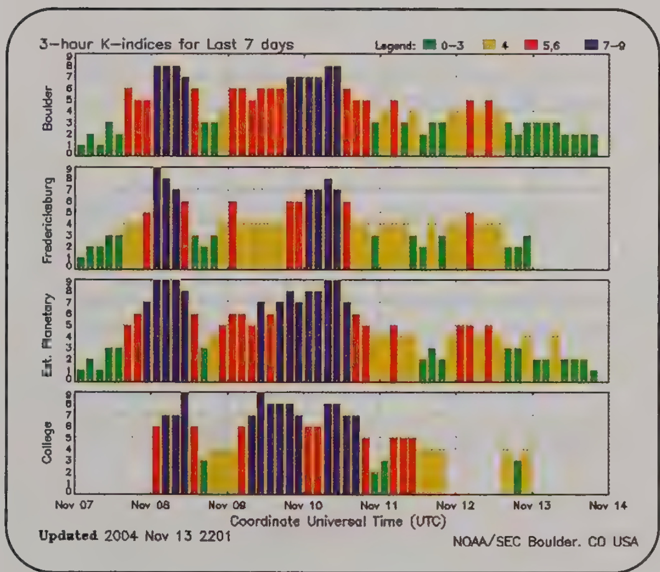

Figure 4. The Kp *levels during the storm of November 7–10, 2004. The geomagnetic activity reached extreme storm levels of 9. (NOAA image)*

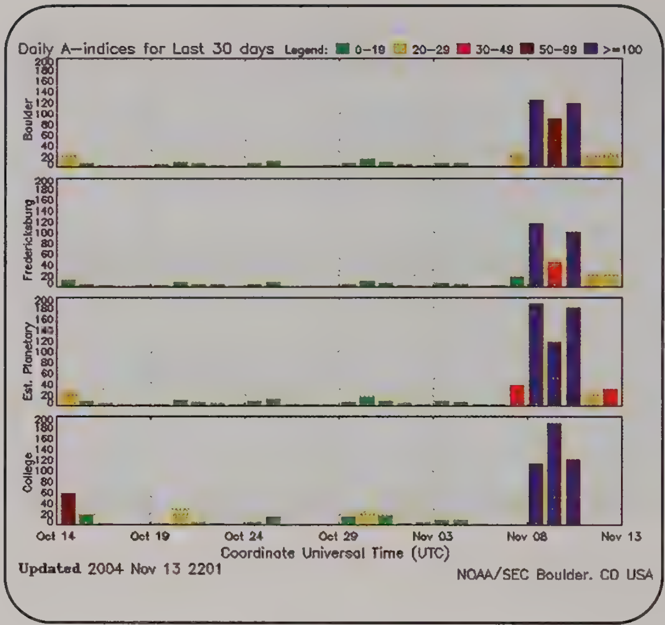

Figure 5. The Ap *levels during the storm of November 7–10, 2004. The planetary* A *index reached as high as 189, indicating a pretty strong geomagnetic storm level. The geomagnetic storm lasted for several days and virtually wiped out communications on MW and HF frequencies. (NOAA image)*

If the IMF is oriented northward, however, this magnetic reconnection does not take place. This should create a barrier against the solar wind and the plasma riding the IMF.

When the IMF connects with the magnetic field around the Earth, and as solar-wind plasma flows into the atmosphere, the geomagnetic field lines become highly active. This is known as a *geomagnetic storm.*

Geomagnetic storms cause a degradation of radio-signal propagation as a result of ionospheric recombination. This recombination is similar to what takes place during the hours of darkness, with a lowering of the frequencies each ionospheric layer can refract. Geomagnetic storms can cause long-term (hours to days) degradation, or depression, of the maximum usable frequencies (MUFs), reducing the critical frequencies by as much as 50 percent of normal.

The occurrence of CMEs of this magnitude is becoming increasingly rare as we enter into the quiet period of the Sun's 11-year cycle of activity. We expect the current cycle, Cycle 23, to end sometime toward the end of 2006 or during 2007. The years 2000–2001 marked the highest point of activity, but that doesn't preclude the occasional surprise, such as the CMEs of November and December 2004. I expect only rare flare-ups of solar activity during February, March, and April 2005, with possible CME activity that could trigger aurora, especially near the Vernal Equinox season this spring. It is more likely that we will see the occurrence of *coronal holes* during this period, which will also trigger geomagnetic storms.

Coronal holes are regions in the Sun's corona (an atmospheric layer of the Sun that could be thought of as one of Earth's atmospheric layers, like the stratosphere) where the corona is darker than the surrounding area. These features were discovered when X-ray telescopes were first flown above the Earth's atmosphere to reveal the structure of the corona across the solar disc. Coronal holes are associated with "open" magnetic field lines and are often found at the Sun's poles. A coronal hole simply means an area where a breakdown in the magnetic fields in the solar corona has occurred. Often, high-speed solar wind is known to originate in coronal holes. This escape of solar plasma and energy streams outward away from the Sun into the solar wind.

March 20, 2004 marks the day when the hours of daylight and darkness are about equal around the world. This is known as the Vernal Equinox. It is well documented that this is one of the two optimal times of the year for aurora. Geomagnetic storms that ignite auroras occur more often during the months around the equinoxes during early autumn and spring. This seasonal effect has been observed for more than 100 years.

As the Sun rotates (one full rotation occurs about every 27 days), the plasma spewing out from the Sun forms into a spiral shape known as the *Parker Spiral* (named after the scientist who first described it). This solar wind carries with it an interplanetary magnetic field, which ever expands away from the Sun in this spiral. Think of one of those rotating lawn sprinklers with jets of water shooting out from the center. You can see a bending or curving of the water lines. As the Earth moves around the Sun, these spiraling solar winds sweep into Earth's magnetosphere. How the magnetic field lines (IMF) in the solar wind interact with the magnetic field lines of the magnetosphere is the key to geomagnetic storms and aurora.

At the magnetopause, the part of our planet's magnetosphere that fends off the solar wind, Earth's magnetic field points north. If the IMF tilts south (we see this when the index known as the *B sub-Z* [B_z] becomes negative), it can partially cancel Earth's magnetic field at the point of contact. This causes the two magnetic fields (the Earth's and the IMF) to link (think of how two magnets link with one magnet's south pole connecting with the other's north pole), creating a magnetic field line from Earth directly into the solar wind. A south-pointing IMF (a negative B_z index) opens a window through which plasma from the solar

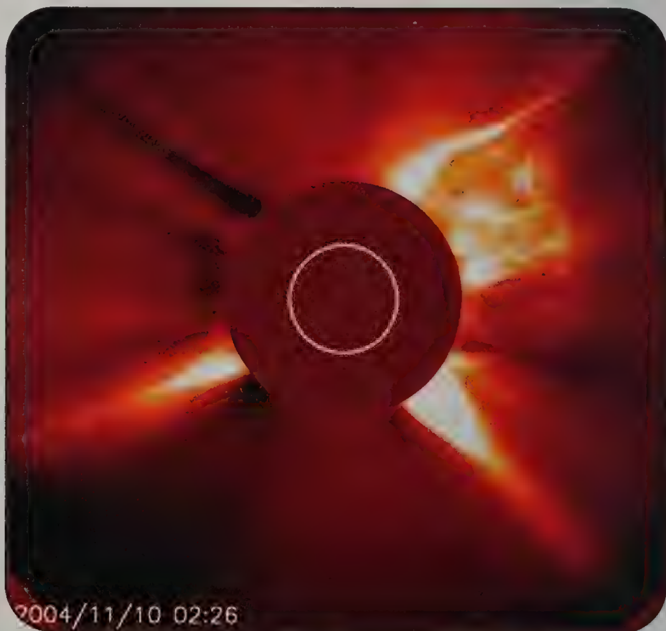

Figure 6. The solar-storm action continued during November 9th and 10th due to the solar activity seen in these LASCO C2 images. (NASA/SOHO image)

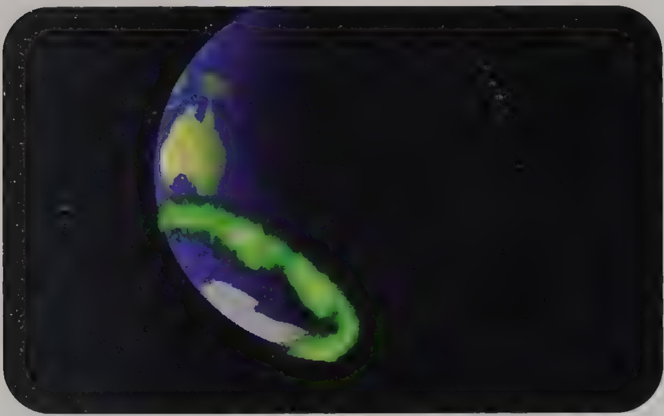

Figure 7. The Polar spacecraft saw the aurora australis (southern lights) expanding and brightening on November 8th. The Earth seems to move from top to bottom due to Polar's orbit. (NASA/The University of Iowa image)

wind and CME can reach Earth's inner magnetosphere, bombarding the gasses of the upper atmosphere.

Earth's magnetic dipole axis is most closely aligned with the Parker Spiral in April and October. As a result, southward (and northward) excursions of B_z are greatest then. This is why aurora is most likely and strongest during the equinoctial months. When you see the solar-wind speed increase to over 500 kilometers per second, and the B_z remain mostly negative (the IMF is oriented mostly southward), expect an increase in geomagnetic activity, as revealed by the planetary *K* index (*Kp*).

Look for aurora-mode propagation when the *Kp* rises above 4, and look for visual aurora after dark when the *Kp* rises above 5. The higher the *Kp*, the more likely you will see the visual lights. However, you don't have to see them to hear their influence on propagation. Signals propagating off the *E*-layer clouds formed during aurora sound raspy or fluttery. When aurora occurs, start looking for VHF DX.

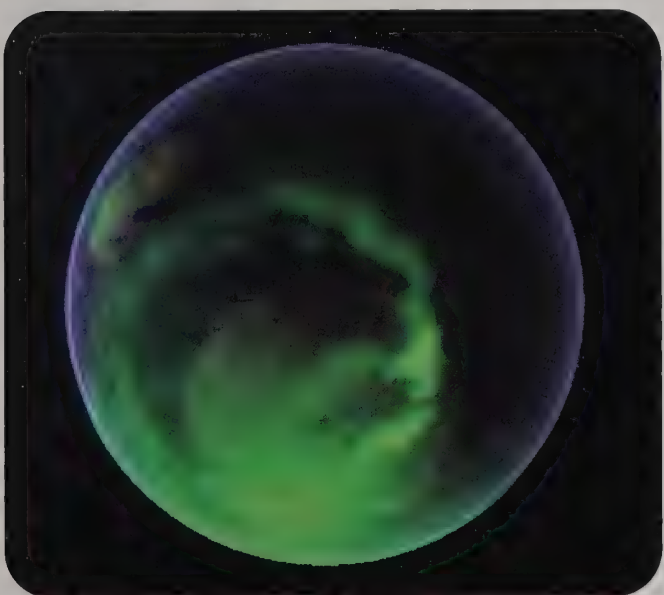

Figure 8. Flying over the South Pole, the IMAGE spacecraft caught this view. (NASA/UC Berkeley image)

Sometimes aurora will enhance a signal's path at very narrow bands of frequencies, while at other times it will degrade the signals. Sometimes signals will fade quickly, then come back with great strength. The reason for this is that the radio signal is being refracted off the more highly ionized areas that are lit up. These ionized areas ebb and flow, so the ability to refract is always changing, and sometimes quickly. I've observed the effect of aurora and associated geomagnetic storminess even on lower HF frequencies.

Radio Aurora

If there are enough solar particles flowing down the Earth's magnetic-field lines and colliding with atmospheric atoms and molecules, ionization occurs. This ionization may be sufficient to reflect VHF and lower UHF radio waves, generally between 25 and 500 MHz. This usually occurs in conjunction with visual aurora, but the mechanism is a bit different and it is possible to have one (visual or radio) without the other.

Using radio aurora, the chances of contacting stations over greater distances than would ordinarily be possible on the VHF frequencies is increased. Like its visual counterpart, radio aurora is very unpredictable. The thrill of the chase draws many VHF weak-signal DXers to work auroral DX.

VHF auroral echoes, or reflections, are most effective when the angle of incidence of the signal from the transmitter, with the geomagnetic field line, equals the angle of reflection from the field line to the receiver. Radio aurora is observed almost exclusively in a sector centered on magnetic north. The strength of signals reflected from the aurora is dependent on the wavelength when equivalent power levels are employed. Six-meter reflections can be expected to be much stronger than 2-meter reflections for the same transmitter output power. The polarization of the reflected signals is nearly the same as that of the transmitted signal.

The *K* index is a good indicator of the expansion of the auroral oval and the possible intensity of the aurora. When the *K* index is higher than 5, most amateur radio operators in the northern states and in Canada can expect favorable aurora conditions. If the *K* index reaches 8 or 9, it is highly possible for radio aurora to be worked by stations as far south as California and Florida. Your magnetic latitude can be found using the map at <http://www.sec.noaa.gov/Aurora/globeNW.html>.

Is Trans-Atlantic Multi-hop Sporadic-*E* possible?

There are a number of VHF DXers who long to see the first transatlantic terrestrial above 6-meter VHF communication between Europe and North America. This accomplishment has eluded the best of operators. Will it ever be possible to span the Atlantic on 144 MHz or above? What mode is the most likely vehicle for this? Some feel that multi-hop sporadic-*E* is the only way.

The months of February through April typically are months of very low sporadic-*E* activity, although it is possible to see dense *E*-layer ionized clouds form during very strong geomagnetic storms that trigger aurora. Is it possible during one of this year's spring aurora events that a multi-hop transatlantic QSO can be made?

One of the hindrances to finding out is not having enough operators dedicated to observing daily conditions. It has not

Figure 9. An ultraviolet view of the aurora is superimposed on a city-lights image from a weather satellite. The TIMED spacecraft made three passes over the U.S., but after the peak of the storm. (NASA/APL/Meteorological Satellite Applications Branch, Air Force Weather Agency image)

been convenient for most radio amateurs to conduct around-the-clock propagation checks across the ocean. For more information on 144-MHz transatlantic propagation, go to: <http://www. df5ai.net>.

One of the ways to overcome the need for manning the VHF bands around the clock in order to catch that first transatlantic opening is to use beacons. However, that could present a problem as well, since traditionally, you would have to be tuning in to the beacon frequencies at all times of the day—manually.

PropNET on VHF

An automated, well-organized beacon effort is being developed on VHF. Much like BeaconNET, which uses additional HF bands, PropNET (http://propnet.org/) gathers beacon data using computers. It helps not only in discovery of openings, but also in discovering details about propagation modes. PropNET is designed to answer the question "If the band is open and no one is transmitting, does anybody hear it?"

PropNET is an ionospheric and propagation probe that runs in the background on a computer and uses an idle radio. Using this powerful tool, a network of strategically-placed stations with optimized equipment can uncover the much sought after transatlantic terrestrial opening on amateur frequencies above 6 meters.

On VHF, PropNET uses APRS technology via either PSK-31, known as PropNET^31, or AX.25 (packet), known as PropNET.25.

PropNET.25 is no simple propagation beacon system. It is a full-function transmit and receive network that not only uses the concept of "digipeating" to extend one's vision of propagation conditions, but is also capable of keyboard-to-keyboard messaging once a path is established.

The concept is simple. Participants embed their 6-cypher grid locator in each transmission. When another PropNET participant decodes that transmission, a symbol is placed on the receiver's computer screen. This symbol corresponds to the transmitting station's exact location on a map. If the band is "open," a symbol appears. If it is not, then no symbol appears. This is much like APRS, but for propagation openings.

PropNET^31 does things much the same way, but does not allow for digipeating. To join in, you need a standard PSK-31 soundcard audio connection between your computer and transceiver (visit <http://www.packetradio.com> for plans), special PSK-31 "modemware," and then the software that controls it all (go to <http://propnet.org/> for software options).

The PropNET work is particularly significant because it is the first generation of propagation beacons for amateur radio's digital millennium. No other system comes close to what PropNET can do. Folks just need to start to think differently about propagation research.

If you are a VHF/UHF and above contester, or maybe going for some distance record, you certainly would want to know what types of propagation could be exploited, especially something no one has ever tried to use. There might not be any other group better equipped to find the answers than PropNET.

To learn more about PropNET, and to download the software and installation and configuration instructions, visit <http://hfradio.org/propnet-info.html>. The official PropNET site is <http://propnet.org/>.

Tropospheric Ducting

Tropospheric ducting activity "down under" was active during October 2004, when a massive tropospheric duct opened VHF propagation between Indonesia and southwestern Western Australia. VK6ZKO, VK6IQ, and VK6HK via the Cataby Repeater <VK6RCT> north of Perth received 144-MHz FM simplex signals in Perth. This propagation repeated in the evening of the same day up to about 2000 WAST. However, no contacts were made and no specific stations were identified due to language problems and the nature of the traffic heard. During the same period, TV SWL specialist Tony Mann identified numbers of Indonesian UHF TV transmitters with both vision and sound received, and also FM transmissions.

During the period between February and April 2005, tropospheric ducting is not expected except rarely in the Northern Hemisphere. This mode is most prevalent during the late summer season.

Meteor Shower Reports

The 2004 *Leonids* shower was dismal according to all of the reports I've seen. One report is from Marianne Gualtieri at <http://members.bellatlantic.net/~vze2n9fe/meteor/leo2004.htm>. It shows a Radio Observation peak rate of 23 meteors per hour.

However, the 2004 *Geminids* shower was much more active. The peak time of the shower is reported to be near December 13 at 2000 UTC, with a rate as high as 160 per hour. Clearly this was the best shower of 2004. Marianne shows Radio Observation peaking at 49 meteors per hour <http://members.bellatlantic.net/~vze2n9fe/meteor/gem2004.htm>. Did you work these showers?

There is only one minor opportunity to try your skill and employ your equipment in meteor-scatter propagation. This will be the *a-Centaurids* meteor shower from January 28 to February 21, 2005, peaking on February 7th at 2245 UTC (sol = 319.319°) with a typical visual rate of about six meteors per hour. However, there is a chance for this shower to intensify with up to 25 or more meteors per hour.

The Solar Cycle Pulse

The observed sunspot numbers from September through November 2004 are 27.7, 48.4, and 43.7. The smoothed sunspot counts for March through May 2004 are 47.2, 45.6, and 43.9, all showing the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from September through November 2004 are 103.1, 105.7, and 113.2. The smoothed 10.7-cm radio flux for March through May 2004 is 114.6, 112.3, and 109.2.

The smoothed monthly sunspot numbers forecast for February through April 2005 are 24.2, 22.4, and 20.2, while the smoothed monthly 10.7-cm radio flux is predicted to be 86.0, 83.3, and 80.7 for the same period, give or take about 15 points for all predictions.

The smoothed planetary *A* indices (*Ap*) from March through May 2004 are 16.9, 15.5, and 14.3. The monthly readings from September through November 2004 are 10, 9, and 26.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing by careful review.)

Feedback, Comments, Observations Solicited!

I am looking forward to hearing from you about your observations of VHF and UHF propagation. Please send your reports to me via e-mail, or drop me a letter about your VHF/UHF experiences (sporadic-*E*, meteor scatter, etc.). I'll create summaries and share them with the *CQ VHF* readership. You are welcome to also share your reports at my public forums at <http://hfradio.org/forums/>. Up-to-date propagation information can be found at my propagation center at <http://prop.hfradio.org/>.

Until the next issue, happy weak-signal DXing.

73, Tomas, NW7US

By Keith Pugh,* W5IU

SATELLITES

Artificially Propagating Signals Through Space

AMSAT Annual Meeting & Space Symposium, ARISS Meeting, and a Cheap Az-El Antenna Positioner

For a satellite operator, October is one of the busiest months of the year. In 2004 the activity started on 6 October when I left for Arlington, Virginia to attend the AMSAT and ARISS (Amateur Radio on the International Space Station) meetings. I returned home on 14 October and immediately left for Microwave Update 2004 on 15 and 16 October. On 23 October I "showcased" satellites at a new ARRL Mentorfest in Irving, Texas. On 29 and 30 October I conducted a satellite forum, performed satellite demos, and ran an AMSAT booth at the Texoma Hamarama at Lake Texoma, Oklahoma. Things then slacked off, with only a trip to Corpus Christi, Texas for another round of forums, demos, and booth activities at the Costal Bend Hamfest on 13 November.

This column will feature the AMSAT and ARISS meetings and construction of a cheap Az-El Antenna Positioner. Numerous inquiries have been answered regarding the Az-El Positioner since its introduction at hamfest satellite demos during the AO-40 heyday. It was pictured in my last column in the Fall 2004 issue of *CQ VHF* and again received attention, so a long-delayed description is presented here.

Photo 1. The AMSAT Board of Directors (left to right): Gunther Meisse, W8GSM; Paul Shuch, N6TX; Lou McFadin, W5DID; Barry Baines, WD4ASW; Dr. Thomas A. Clark, W3IWI; Robin Haighton, VE3FRH; and Richard Hambly, W2GPS.

AMSAT Annual Meeting and Space Symposium

BoD Meeting: Activity at the Crowne Plaza Hotel in Crystal City, Virginia started with the AMSAT board meeting on 7 and 8 October. The newly elected and returning board members were introduced by retiring President Robin Haighton, VE3FRH (photo 1). After a review of the agenda, the first order of business was election of officers for 2004–2005. After nomination by Robin Haighton, Rick Hambly, W2GPS, was elected to the office of president. From that point on, Rick presided over the meeting. Rick presented his nominations and his logic for revision of the slate of offices. After some discussion, the remaining offices were filled, and the new slate of officers is shown in photo 2, with the exceptions of Manager Martha Saragovitz and Vice President of Engineering Stan Wood, WA4NFY.

Robin Haighton and Gunther Meisse, W8GSM, set the stage for the remainder of the meeting with president and trea-

Photo 2. AMSAT officers (left to right): Secretary Steve Diggs, W4EPI; Treasurer Gunther Meisse, W8GSM; Executive Vice President Lee McLamb, KU4OS; Vice President Operations Mike Kingery, KE4AZN; President Richard Hambly, W2GPS; Vice President of Human Spaceflight Frank Bauer, KA3HDO; and Vice President of Marketing and User Services Barry Baines, WD4ASW.

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Photo 3. Host of 2005 AMSAT Space Symposium Nick Pugh, K5QXJ (left), with Barry Baines, WD4ASW.

surer reports for 2004 and a proposed budget for 2005. Meisse presented a North American Fund Raising Feasibility Study followed by the results of a membership survey conducted in 2004. These two items were then discussed by all and became part of the strategy for the future as outlined by Hambly.

Key to this strategy is the AMSAT vision statement: "Our vision is to deploy high earth orbit satellite systems that offer daily coverage by 2009 and continuous coverage by 2012…" This vision requires two high-earth-orbit (HEO) satellites by 2009 and three by 2012. The first of these satellites will be the Phase 3E project from AMSAT-DL, and the other two will be Project Eagle satellites from AMSAT-NA. Again, international cooperation will be required to bring this vision to fruition. Hopefully, the schedule presented in the vision statement can be improved upon.

Reports from all of the standing committees and functions then were presented and discussed. Special emphasis was placed on the ECHO Launch Report by Chuck Green, NØADI, and the Project Eagle Status and Budget by Jim Sanford, WB4GCS, Project Eagle Manager, and Rick Hambly, W2GPS. The Education Report by Lee McLamb, KU4OS, received much attention, since it too is an important part of AMSAT's vision for the future.

The meeting was wrapped up with selection of 2005's meeting location and the usual "ata-boys" and "ata-girls." The 23rd Space Symposium and AMSAT-NA Annual Meeting will be held in the fall (October or November) of 2005 in Lafayette, Louisiana. Hosts for this symposium will be Nick Pugh, K5QXJ, and others from the Acadiana Amateur Radio Association. Nick and Barry Baines, WD4ASW, are pictured in photo 3 at the symposium during an intermission for an ISS pass. Minutes of the meeting are available in the *AMSAT Journal*.

Space Symposium: The Space Symposium began on Friday afternoon. The activity commenced with a president's welcome and was followed by the presentation of ten papers generally related to the AMSAT Eagle Project and ground-station hardware. Project Eagle topics included Project Eagle Status Report, Eagle's Radiation Environment, a Simulator for the AMSAT Eagle Spacecraft, C-C Rider Revisited, and Software Defined Radios—The Future is Now. Other topics included Starting AMSAT's Lessons Learned Process, Bias Tees for Satellite Receiving Systems, and From Sizzling Hot BBQ to Cool BUD-Lite—

Photo 4. The Space Symposium ARISS panel (left to right): Japan, Keigo Komuro, JA1KAB; USA (ARRL), Rosalie White, K1STO; Canada, Robin Haighton, VE3FRH; Russia, Sergey Samburov, RV3DR; and USA (AMSAT), Frank Bauer, KA3HDO.

A Cheap Az-El Antenna Positioner

Two photos in the last column (Fall 2004 *CQ VHF*) illustrated the Cheap Az-El Positioner. The first showed it being used to support a Kent Britain, WA5VJB, Cheap 70-cm Yagi for AO-51 data gathering. In the second photo it was being used to support two Cheap Yagis for satellite contacts at the North Texas Balloon Project (NTBP) balloon launch last September. These photos prompted several questions, so here is a little more detail on the positioner. The complete positioner without antennas is shown in photo A. It is mounted on a standard RadioShack 3-foot tripod and consists of several parts as follows:

The horizontal boom (overall length 24 inches) is actually made of several parts. There are two pieces of 1-inch PVC glued into a 1-inch PVC T. Inside the boom is a 24-inch length of 1-inch wooden dowel to give added strength (this primarily prevents crushing the PVC pipe when antenna clamps are tightened) and to provide a place to attach the elevation protractor and indicator (fishing leader and weight) with a stud (wood screw on one end and machine screw on the other).

Photo A. The completed Az-El Antenna Positioner assembly mounted on a tripod. The dish mounts on the right and the Yagi on the left. (Note azimuth pointer.)

Photo B. The horizontal boom and positioner arm on the left showing the wooden dowel and elevation indicator assembly, and the elevation bearing assembly on right. (Note hose clamps for friction adjustment.)

Photo C. Assembly of the horizontal boom and elevation bearing.

A positioning arm is made of 1-inch PVC, just like the horizontal boom. It is glued to the 1-inch PVC T that forms part of the horizontal boom and is closed with a 1-inch PVC cap. Inside the positioning arm is a combination of 1-inch wooden dowel and lead shot to form the appropriate counterweight.

Support for the horizontal boom is provided by an assembly of a $1^1/4$-inch PVC T and two pieces of $1^1/4$-inch PVC pipe. The two pieces of $1^1/4$-inch PVC pipe are glued into the $1^1/4$-inch PVC T. One of these pieces is hard to see and is actually only a "bushing" on one end of the $1^1/4$-inch T. The longer piece of $1^1/4$-inch PVC is "slotted" with a hacksaw so that it, along with a hose clamp, forms the elevation friction adjustment.

The 1-inch PVC assembly passes through the $1^1/4$-inch assembly, which becomes the elevation bearing with a friction adjustment as mentioned above. I chose 24 inches as an overall length and originally clamped a 2-foot by 3-foot BBQ grill dish and down converter to the short end of the 1-inch PVC assembly (next to the "bushing" end of the $1^1/4$-inch PVC T). The longer end (next to the 1-inch PVC T) was used for the 70-cm Cheap Yagi.

The azimuth assembly consists of a 1-inch PVC pipe clamped into the tripod and $1^1/4$-inch PVC slipped over it and glued to the $1^1/4$-inch PVC T that also includes the elevation bearing. The azimuth protractor is mounted on a piece of wood and the assembly drilled so that it will slide over the 1-inch PVC pipe attached to the tripod. The $1^1/4$-inch azimuth (vertical) pipe is also "slotted" with a hacksaw and equipped with a hose clamp to form an adjustable azimuth friction adjustment. An aluminum pointer is clamped to the vertical piece of $1^1/4$-inch PVC by the friction-adjustment hose clamp and extends out to the azimuth protractor.

Photo D. RadioShack tripod showing the azimuth bearing post and azimuth indicator.

Taming the Grid Dish for Space Communications. Friday evening activity included an informal dinner, Poster Sessions, and the President's Club Meeting.

Saturday morning began with Chuck Green, NØADI's colorful and informative presentation on the ECHO launch campaign. It started with final preparations in the U.S. and ended with the launch at Baikonur. The presentation was well illustrated with slides and was also an excellent travelogue of Russia and the many unique experiences Chuck encountered. A description of the ECHO commissioning process followed.

Gould Smith, WA4SXM, wrapped up the ECHO papers with a discussion of ECHO as an Educational Tool. Making Sense of Sensors was the topic of a paper by Alan Bloom, N1AL. The last presentation of the morning was the P3E Status Report by Peter Guelzow, DB2OS, President of AMSAT-DL. P3E is being built in a leftover AO-10/AO-13 spaceframe with "off the shelf" hardware. A late 2005/2006 launch is planned to "fill the gap" in HEO satellites left by the early demise of AO-40. As mentioned earlier, it will be the first HEO satellite in the new AMSAT vision.

Photo 5. Left to right: Perry Klein, W3PK; Larry Brown, W7LB; and Howard Long, G3LVB.

Photo 6. Graham Shirville, G3VZV (left), and Drew Glasbrenner, KO4MA.

Photo 7. Bob Bruninga, WB4APR.

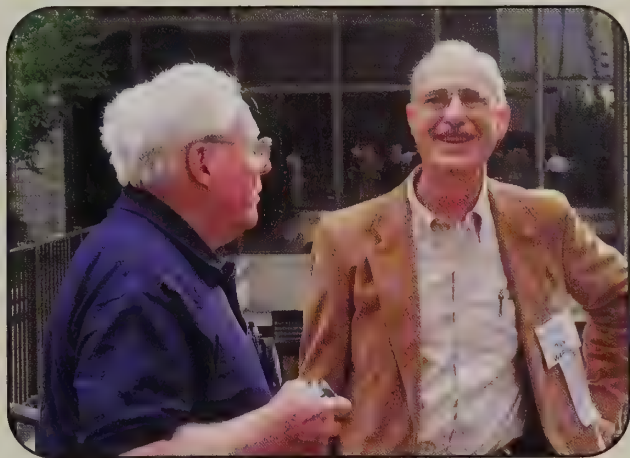


Photo 8. Bill Tynan, W3XO (left), and Dick Daniels, W4PUJ.

Shown above are some of those who attended the Saturday afternoon ARISS panel discussion led by Frank Bauer, KA3HDO, and several of the international delegates.

Saturday afternoon was devoted to ARISS and related topics. It began with a panel discussion led by Frank Bauer, KA3HDO, and several of the international delegates (photos 4 through 8). It was during this time that "SuitSat" was proposed by Sergey Samburov, RV3DR, and the Russian delegate. SuitSat fired the imaginations of many of the members of the audience and also occupied quite a bit of the ARISS meeting following the symposium. Two teachers—Rita L. Wright, KC9CDL, and Carrie Cunningham, N7NFX—presented the fascinating stories of their International Space Station school contacts. These stories were truly inspirational. A discussion of Voice/IP Communications for the ARISS Program followed.

Saturday's symposium session ended with a presentation by Graham Shirville, G3VZV, on the SSETI Express satellite being built by European universities and sponsored by the European Space Agency (ESA). Among other features, this satellite will contain a copy of the 2.4-GHz transmitter that is currently flying on AO-51. AMSAT-UK is leading the amateur radio effort on this satellite, which is now scheduled for a mid-2005 launch.

The AMSAT Annual Meeting and Awards Ceremony completed the afternoon session. Highlights of the board meeting were presented, officers were introduced, and awards (too numerous to mention) were presented to many AMSAT volunteers.

After "Thruster Firings," or "attitude adjustment," an excellent dinner was served, followed by the keynote speaker's program and prize drawings. The keynote speaker was Astronaut Carl Walz, KC5TIE, veteran of several shuttle missions and a tour of duty on the ISS. Carl's commentary and pictures were fantastic!

Sunday morning began with the Field Ops Breakfast led by Barry Baines, WD4ASW. This has become the annual "rallying point" for the AMSAT Area Coordinators from all over the country. Ideas are exchanged, friendships are renewed, and plans are coordinated for the coming year.

The Sunday morning symposium session included reports of current and upcoming university satellite projects. In general, these projects were presented by the students involved and were well received. Several other topics were presented, but the one that caught the imagination of this author was "Why Is

Spaceflight So Difficult? A Look at Kinetic Energy Requirements for Orbital Flight" by Daniel Schultz, N8FGV. As usual, Dan took a somewhat dull topic (in light of the recent "X Prize" awarded to the Rutan Space Plane) and made it entertaining and humorous.

An excellent AMSAT Space Symposium was concluded Sunday afternoon with an organized trip to the new Udvar – Hazy Facility of the Smithsonian Air and Space Museum at Dulles Airport. Anyone with any interest in aviation and space would be impressed with this large facility, which contains examples of aviation and space ranging from the Wright Brothers to the Space Shuttle Enterprise. Although not present at the opening and for our visit, it now contains the test article for OSCAR-1. Other notable examples include the Enola Gay B-29, Concorde, Boeing 707 Number 1, F-35 Prototype, J-3 Piper Cub, and many other military and civilian aircraft.

ARISS International Annual Meeting

The 2004 ARISS International Annual Meeting was held in conjunction with the AMSAT-NA Annual Meeting and Space Symposium. The last time this occurred was several years ago, when the ARISS meeting was held in conjunction with the AMSAT-UK Space Colloquium at the University of Surrey in England.

On Monday morning, 11 October 2004, the meeting was "kicked off" by Frank Bauer, KA3HDO. The first order of business was a report of the election of officers by Robin Haighton, VE3FRH. All of the incumbents were re-elected. International team reports followed: ARISS Europe Report (via teleconference), Gaston Bertels, ON4WF; ARISS Canada Report, Robin Haighton, VE3FRH; ARISS USA Report, Frank Bauer, KA3HDO, and Rosalie White, K1STO; ARISS Russia Report, Sergey Samburov, RV3DR; and ARISS Japan Report, Keigo Komuro, JA1KAB.

Monday afternoon was filled with reports from the following committees: Public Relations, Administrative, Hardware, School Outreach/School Selection, Operations, and Project Selection & Use. Some of this carried over into the Tuesday morning session. Topics ranged from designing ISS QSL cards to VoIP and the popular SuitSat proposal. Coordination of all of this activity on an International basis is challenging and interesting.

Monday evening nearly everyone enjoyed a visit to the International Spy Museum in Washington, DC. Dinner was nearby in China Town at a Mongolian barbecue. A good time was had by all.

Tuesday the committee reports were finished. Financial discussions were led by Robin Haighton, VE3FRH. Frank Bauer, KA3HDO, moderated Moon, Mars, and Beyond, Group Strategy Session. Initial plans for the 2005 meeting were laid, with an offer from AMSAT-UK to host the meeting in conjunction with the AMSAT-UK Space Colloquium. The meeting was adjourned Tuesday afternoon after further discussion and assignment of action items.

Next Issue

The activities reported on in this issue were well worth the time I spent attending them. I hope you have enjoyed the report, particularly those of you were not able to be there. My next column will feature a plan for a ground station that will work all of the modes supported by AO-51.

73, Keith, W5IU

DR. SETI'S STARSHIP *(from page 84)*

esis, which the SETI experiment contemplates, is it didn't have to.

The odds of life evolving elsewhere may be pretty long indeed. The best chance for SETI success may depend on the idea that life did not evolve independently, but was seeded everywhere through the mechanism of *panspermia.* No bioastronomer has yet disputed the possibility that microbial life can successfully traverse the distance between the stars and thrive in a new planetary environment. Thus, life need not generate independently in disparate regions; a universe teeming with life merely requires one genesis event coupled with a transport mechanism. In research, that mechanism tentatively has been demonstrated by Chandra Wickramasinghe and the late Sir Fred Hoyle.

To me, microbial panspermia is a far more compelling explanation than the alien-progenitors-in-spaceships scenario, because it does not require that we warp the laws of nature or contemplate technologies not in evidence. Perhaps we really *are* all brothers beneath the skin.

Were it not for Drake's Equation, today astrobiologists would not even know which of these assumptions to attack. As it stands, Drake has given us a handle on where to start. Meanwhile, there remain those who quibble about quantifying seven factors that Drake intended us merely to contemplate. They help us to establish a low value for at least one Drake Equation factor—the fraction of life forms that manifest intelligence. ■

A bit of thinking about all this led to my reading the article on rain-scatter communications by WA1MBA and asking some questions on the NLRS reflector. The folks in the know indicated that it was very possible that rain had enhanced our paths and that it was something pretty common.

Starting to Get Into the Mindset

In that summer of 2003 we began to give some thought to taking advantage of the rain. When Gene headed out, instead of hoping that the weather was warm and sunny, we hoped that something would be brewing in terms of rain or storms.

Other folks in the NLRS were starting to "tune in" to the mode that summer. On June 10th there were some good storms in EN34, the Minneapolis-St. Paul area. I don't recall exactly how I knew the guys up there were on, but someone let me know or I read it on the NLRS reflector. It was like a 10-GHz DX opening!

I first worked Gary, WØGHZ, in EN34lx with 5×4 signals, and then Bob, WØAUS, in EN35ka, and Bruce, W9FZ, also in EN34. Bruce was on his balcony from his apartment building! All 10-GHz contacts were worked on FM, as the Doppler shift from this particularly intense storm was quite extensive. It was too great, as it really made SSB signals unintelligible. CW would have been just fine, but we just did not need it to make the contacts. The signals were really good with just a bit of noise and flutter on FM.

The typical beam heading to that area is in the 45- to 50-degree range. However, I was pointed at 35 degrees and the direct path was roughly 325 km (200 miles). I then worked Gary, WØGHZ, on 5.7 GHz using SSB. That signal was not as distorted, as the reduction to the lower frequency was not affected as much by the Doppler shift.

Shortly thereafter, on July 15th, Bruce, W9FZ, made a visit to his folks' farm in Wisconsin, EN43tq. The direct-path heading was 80 degrees and about 475 km (295 miles). We were wondering if the standard tropo forward scatter would be good enough to make a contact, but we were again blessed with some thunder clouds and rain in the midpoint of the area. I ended up being pointed in the 95-degree direction, but Bruce was pretty much on direct path. However, direct-path lineup on each end resulted in no signals heard. Signals were again "auroral" in nature and SSB strength was 5×5 on both sides. It was a very easy contact and a new grid on 10 GHz for me!

Making a Point of Using the Rain

Folks were really fired up about the rain-scatter contacts being made in the area. There was lots of talk about how it would be "next year," when we would really make things happen. However, there were still some interesting things in store for 2003.

I had recently finished my 24-GHz dish project, and Gene and I were using the dishes to experiment with DX and learn the propagation as best we could. On the night of August 26th, I noticed a storm cell that was fairly strong to my southeast. A look at the radar showed that Gene was not in the cell and was due south of it in his home QTH in EN22ge. Thus, both of us were outside of the storm and not too worried about getting wet.

I quickly went to look at a road map. Using a protractor to somewhat interpret the county lines from the radar over to the road map gave me a rough idea of where I thought a scattering point might be. The use of the protractor with the map then gave me a beam heading. For Gene the storm was pretty much due north. We both could see the lightning flashes in the distance from our particular viewpoints.

It was nice for me, as I had a pretty decent heading through the southeast part of town, so I just set up the dish on my back patio. Gene had to head out just north of Schleswig, Iowa in order to get away from the local clutter.

We had worked the direct path on 24 GHz many times , as we are only 119 km (74 miles) apart. The heading to Gene typically was 149 degrees, with his heading typically being 329 degrees.

We started out pointed at the presumed scattering point, about 130 to 135 degrees for me, while he was pointed basically north toward the flashes in the distance. We went back and forth for a half hour with nothing heard at all. I also periodically went back to the computer radar map to see if things were moving out of path. Both of us tuned around and made slight variations in the azimuth plane. We then decided to elevate the dishes slightly to see what might happen. Within just a few minutes, I heard Gene's "auroral"-sounding CW beacon. In a burst of excitement, I called Gene on his cell phone so he would not move the dish! He then peaked up on me and we had very good signals on SSB! Over a half-hour's time we experimented with the elevation and azimuth on both sides. We chatted quite a bit and also realized that the Doppler shift did not really make the SSB unintelligible. However, it definitely shifted the frequency, so we had to use the RIT to keep in adjustment. The shift experienced was a solid 1 kHz.

We did not have a good way to measure elevation at the time, as our bubble levels were maxed out, but I would guess the elevation was in the 5- to 10-degree range. We both took side-view pictures of the dishes to note the level of elevation. It was a very neat contact, and doing it at night with the flashes in the distance made it quite exhilarating. My final azimuth heading was about 135 degrees, about 15 degrees off true heading. Gene was still pointed pretty much due north toward the storm. There was quite a scattering angle!

I got around to posting the information on the NLRS reflector. Jon, WØZQ, indi-

Photo D. The 5.7- and 10-GHz dishes at KMØT pointed toward EN34 with a bit of elevation.

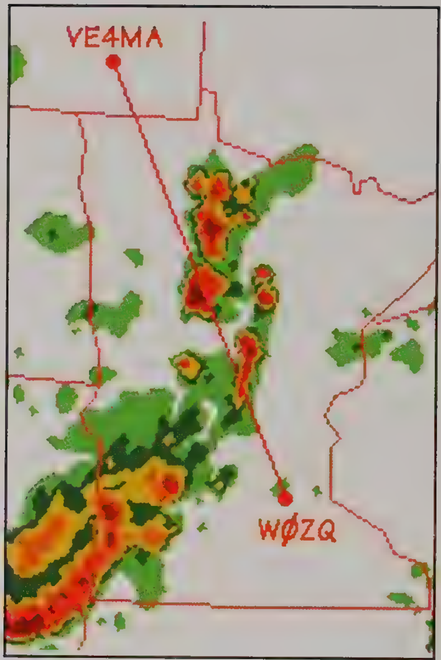


Figure 2. Direct path of WØZQ to VE4MA. Note the strong cell at midpoint.

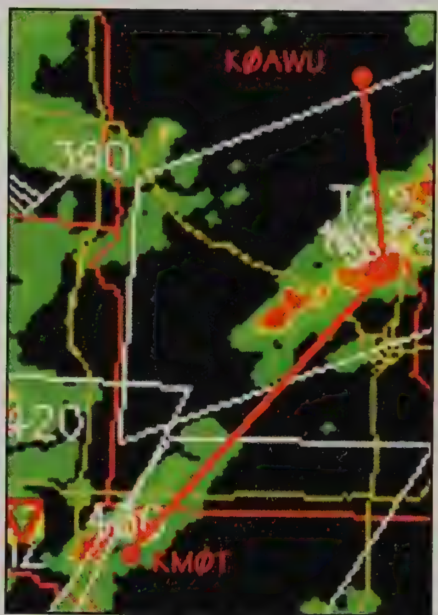


Figure 3. Unisys radar image of KMØT to KØAWU.

cated that there was no record posted for 24-GHz rain scatter, so I sent that down to Al Ward, W5LUA, and he added it to the list.

Rain Scatter in Contests

Other notable rain-scatter contacts came during the second weekend of the 2003 ARRL 10 GHz Contest. The first day of the contest was pretty dry and propagation was not all that great. However, the next morning some interesting things happened. A small amount of rain was present on that Sunday morning, and the radar indicated that it was between the EN34 twin cities area and down here in northwest Iowa. I managed to catch some fellows on liaison frequencies and started calling up to the EN34 area (photo D).

On direct heading, I managed to work Eric, KT8O, in EN34. Eric was using an old homebrew, very-low-power transverter on 10 GHz with 432-MHz IF and DSS (digital satellite system) dish. Power output was approximately 20 mw. A bit of beaconing on my part enabled Eric to find me, and we worked with fairly comfortable signals on SSB. I was then able to work Chris, NØUK, and Gary, WØLJC, on SSB. Signals were fluttery in quality although stable in strength. The rain was causing just enough forward-scatter enhancement to make these 300-km (180-mile) plus paths. Eric, up on the roof of his apartment building in the middle of the cities, was able to contact me on and off to help get me in touch with the other guys on 10 GHz. Who says a 10-GHz liaison does not work?

I then decided to just call CQ up there, as I knew there might be others on that morning. Sure enough, Gary, WØGHZ, came back and we worked on CW. I kept calling and I heard a blip of something, but it was gone right away. I looked up at the band scope on the 756 Pro-II (which is part of the IF setup) and saw a signal quickly moving down in frequency. I tuned down to where it appeared to stabilize and there was Bob, WØAUS, in EN35! Bob had just heard the news and ran outside to set up his portable dish. He had just turned it on, so he was really drifting! We ended up having a nice chat on 10 GHz from his lakefront area, which normally would be pretty much impossible, since the elevation is very low.

Bob and I also attempted to try 5.7 GHz from his location, but the rain stopped and all the excitement was done for the day!

Other Awesome Contacts!

VE4MA and WØZQ: Jon, WØZQ, has always been good at watching propagation conditions. Early on the morning of July 29, 2003, Jon posted to the NLRS reflector that the weather was looking good (or bad, depending on your viewpoint!) for a possible shot later on in the day to Barry, VE4MA, up in Winnipeg, EN19lu. Jon indicated that strong storms were supposed to line up well west and north of Minneapolis as they traveled from west to east. At least that was the prediction, and he was not to be proved wrong!

Barry got the note and indicated he had a few housekeeping things to take care of regarding his tower-mounted 10-GHz system, but he would be ready if the events panned out.

At around 6 PM Jon again posted that the storms were "looking good" and he was "crammin down dinner" and heading out. He was going to a location near Burnsville, Minnesota EN34is, which has a great horizon to the northwest. Jon said that he would listen on the odd minutes and send some 10-GHz beacon RF on the even minutes while he was pointed about 333 degrees, basically on direct path.

Well, Jon did not have time to send any beacon RF. When he arrived at the site and turned on his dish/transverter, there was a long-winded CW CQ heard. The signal was 5×9+ and went on for a minute. Jon figured it was a local who had seen the postings earlier and was CW beaconing and fishing for QSOs. When the CQ ended and was signed by VE4MA, Jon just about fell over! Jon and Barry quickly contacted one another and completed the QSO at around 6:50 PM. Jon had 5×5 to 5×7 signals, while Barry's signal to Jon was 5×9. Signals were "auroral"-sounding in nature and not completely distorted. Jon said that SSB and FM were very likely, but they just did not get around to trying. The heading was pretty much direct path (figure 2). Jon heard Barry's signal for the next 30 minutes until it faded away. Barry indicated that he heard Gary, WØGHZ, and was sending a 5×6 report, but he never got back a report on his end.

The contact between Jon and Barry ended up being about 632 km (393 miles). This was good enough to be the fourth farthest rain-scatter contact in the continental U.S./Canada on 10 GHz. Jon was running 1 watt into a 22-inch offset portable dish setup, while Barry was running 50 watts via elliptical waveguide to an 18-inch offset feed dish.

KMØT and KØAWU: On April 18, 2004 there was a good storm brewing near Minneapolis/St. Paul. Some cells were lined up from Duluth to the slight northeast and southwest of the twin-city area. It was raining on and off down here with lots of wind, and some storms were moving into the area.

I had just finished "buttoning-down" the station, disconnecting cables, etc., when I happened to check the NLRS

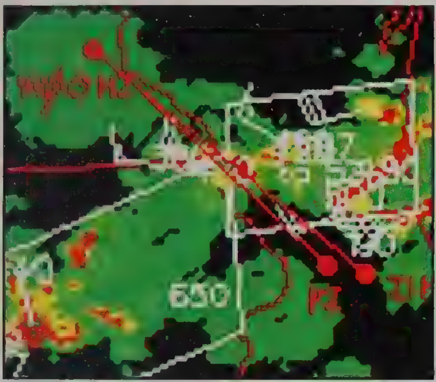


Figure 4. Paths for WØGHZ to N4PZ and W9ZIH.

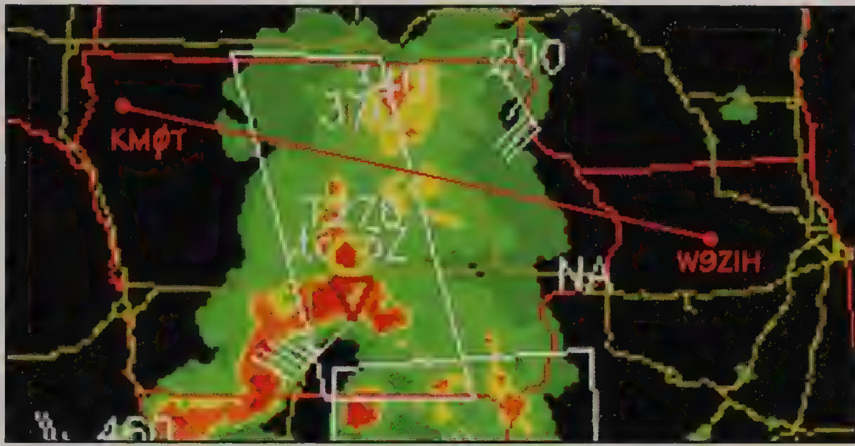


Figure 5. Unisys radar image for direct path of KMØT to W9ZIH.

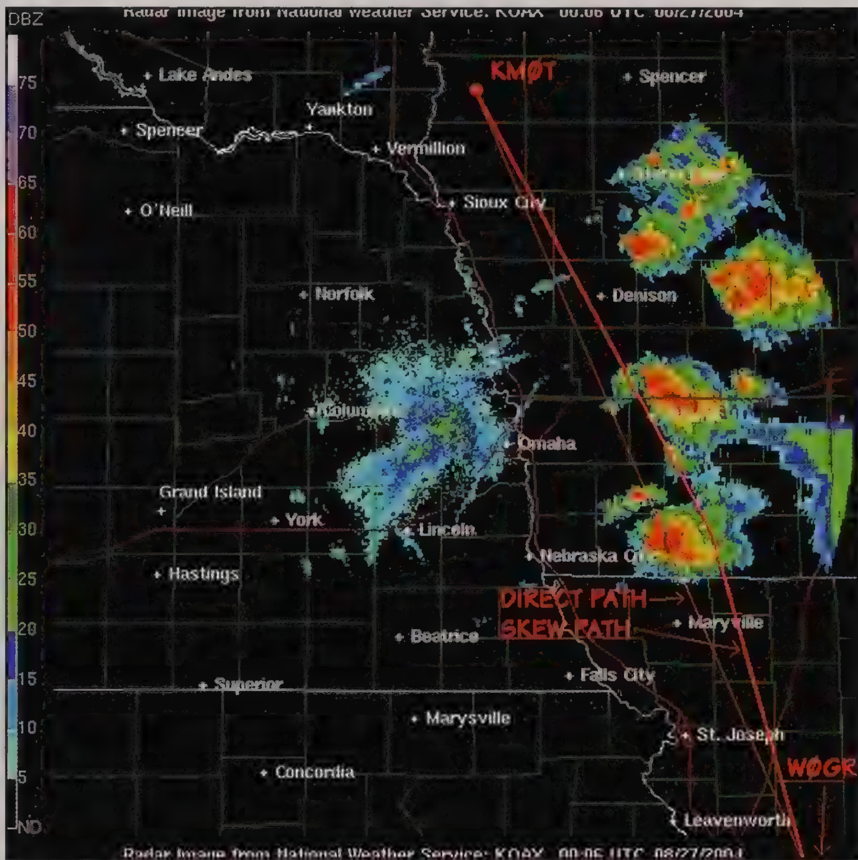


Figure 6. NOAA radar image saved from KØSM's RainScatter program. Paths shown by KMØT edits.

reflector. Gary, WØGHZ, had a simple message: "Working KØAWU right now S9++ on 10 GHz." I sat there for a minute wondering what I should do. With the wind blowing and storms in the area, I knew I would not have much time, as I don't like being connected when there is lightning around!

I ran downstairs and fired up the IF rigs and transverters on the tower and spun the dishes to about 40 degrees. I then started to elevate the dishes to the horizon and began to see radar blips on the 756 Pro-II band scope! A quick listen after a minor peaking of antennas revealed KØAWU calling NØUK on CW. Bill was 5×5 with very good "auroral"-sounding signals but with quite a bit of fading. The fading could easily be attributed to my dishes being bounced around by the 35+ mph winds we were having, which made the crank-up tubular tower bounce around quite dramatically.

I waited for about two minutes as Bill made repeated calls to Chris, NØUK, but it was apparent that he was not being heard at that time. I could not wait any longer, so I started calling Bill. After two calls he came back to me and we exchanged reports! I imagine that Bill was quite surprised, not knowing I was even going to give him a try! Signals on his side were 5×9 and Bill worked four other stations as well. It was a good distance for non-coordinated rain scatter and a new grid! I then quickly shut down everything, disconnected cables, and went about my normal everyday business of chasing the kids.

The distance was approximately 493 km (306 miles) and was about 15 degrees off direct heading from my side (figure 3). Bill later indicated that I had peaked about 10 degrees east of direct, which made sense. I did not notice much Doppler shift on his signal, but we never tried any voice modes; elevation was not a factor, as both of us had the dishes level at zero degrees.

WØGHZ and N4PZ & W9ZIH: Gary, WØGHZ, and Steve, N4PZ, had been attempting to work on 5.7 GHz via tropo for some time. Steve had just put up a large 7.5-foot dish with 10 watts on 5.7 GHz and had been working some folks.

On May 5, 2004 there was a very good storm system between Gary and Steve. Gary contacted Steve to attempt a QSO. They worked in the evening at around 0310 UTC on 5.7 GHz with 5×9 signals, and followed that with a contact on 10 GHz, also 5×9 signals both ways. All modes were used—CW, FM, and SSB. This was a forward-scatter, direct-path rain-scatter contact, so the Doppler shift was not too bad, as SSB was very intelligible and the CW signal had a typical "auroral" sound. N4PZ was located in

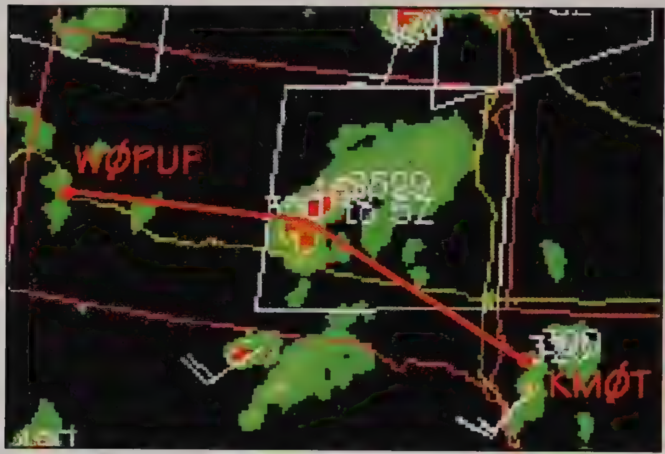


Figure 7. Unisys radar image of KMØT to WØPUF path.

Photo E. WØPUF's signal as it showed up on the 756 Pro II Bandscope.

EN52gb, which gave a distance of 480 km (269 miles) to Gary's QTH in EN34LX. Gary runs a 4-foot dish on 5.7 GHz with 20 watts and waveguide feed from the shack, while he runs an 18-inch DSS dish with the transverter and 2 watts at the feedpoint for 10 GHz.

Right after that, N4PZ called Ron, W9ZIH, in EN51NV to ask him to get on the air. Gary and Ron were able to work on both 5.7 and 10 GHz with little effort. Gary gave Ron 5×3 signals on 5.7 GHz and 5×8 signals on 10 GHz. WØGHZ's contact times with W9ZIH were about 15 to 20 minutes later than the QSOs with N4PZ, so the rain-scatter conditions lasted for quite some time. Also, the distance was extended a bit for the contacts with Ron—480 km (298 miles), good hauls on the microwave bands for sure! The path was essentially the same with both N4PZ and W9ZIH—only a few degrees different and posing no pointing issues with the large thunderheads in between (figure 4).

KMØT and W9ZIH: On May 24, 2004 I noticed that some light rain, with some "good yellow," was showing up on radar around central to eastern Iowa. It was looking as if it might be the right spot for a try with Ron, W9ZIH, in EN51nv. I gave Ron a quick phone call to see if he could get on, and he said he had some time to give it a shot.

I got his direct heading, and the dishes lined up as we went with a 2-meter liaison on 144.260 MHz. The storm was a fairly thin line of precipitation that ran from slightly southwest to northeast. The direct-path precipitation line was pretty thin, as it was showing just normal to light rain with more intense cells just above and below the direct path.

We started out on 5.7 GHz and made short work of the contact. Signals were 519 with no distortion. We followed that up on 10 GHz with 559 signals on CW and also chatted there on SSB, albeit a bit weak. Again, no distortion was noted, but a slight watery sound was present on both bands, which might have been caused by a bit of multi-path. Ron and I discussed this for a minute afterwards on 2 meters and then decided to go back to 10 GHz. He heard me call and fade out; the path had dropped out that quickly.

It appeared to me that the direct path showing just rain, in conjunction with no distortion except some multi-path warble, was just enough and close enough to the midpoint between us to give the signal a boost (figure 5). It was evident that without the rain, nothing would have happened.

Photo F. KMØT's 24-GHz dish pointed up towards the rain squall.

Ron's QTH in Illinois is EN51nv, for a path distance of 615 km (382 miles). This was another new grid on both bands. Later on I was informed by Jon, WØZQ, as he looked over my report on the NLRS reflector, that the 5.7-GHz contact was good enough for the U.S. continental rain-scatter record! Cool!

KMØT and WØGR: Garth, WØGR, and I had been trying to work on 5.7 and 10 GHz for quite some time over the last few years. We had a brief tropo opening on August 3, 2004 and managed to work on 5.7 GHz, but we were not able to make it on 10 GHz. A few weeks later, on the 27th, some good storms came along. The storms were pretty large—kind of strange for that late in the season—but I called Garth on the phone to see if he wanted to give it a shot.

The cell was large and wide, and right smack dab at the midpoint of the path, so it looked very good. There was also opportunity on each side of direct, but going head-on seemed to be the place to start. We spent 25 minutes or so beaconing back

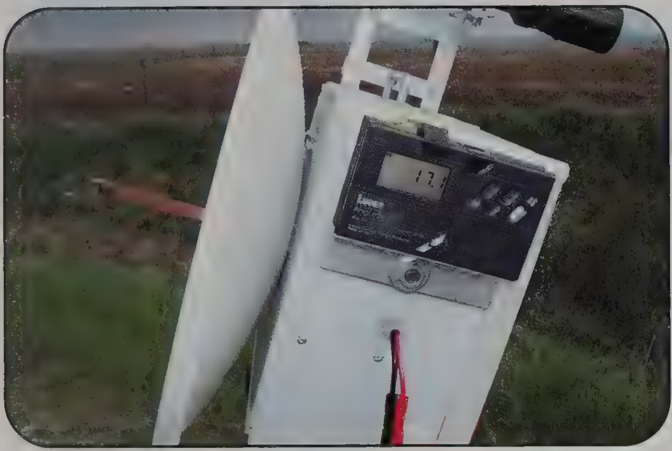


Photo G. Lucas DP45 AngleStar Digital Protractor showing 17.1 degrees elevation.

and forth for five minutes at a time, but nothing was heard. This seemed odd, as the distance was not all that great and the storm looked to be perfect for what we were trying.

With that, I began to swing my heading around a bit and also bumped the dish elevation. That's when I found Garth and gave him a quick call on 432 MHz, as that was where we were doing the coordination. I asked him to keep the beacon going, as I was trying to get the signal peaked.

It turned out that the peak was on the east side of the storm, with about 3 to 5 degrees of elevation. No signals were heard with the dish on the horizon. When peaked, the signals were extremely weak and distorted. This was very much unexpected and it took some time to get hooked up. As it was a 50-50 chance, after trying the direct path for some time we then tried to the west of the cell. Lots of time was spent there, but with no success. After that, signals were found on the east side of the direct path. One never really knows what will work out, and guessing correctly can save some time!

The distance to WØGR in EM38AX was 495 km (308 miles). Signals were 5-0 to 5-1 with extreme distortion, so CW was the only mode we could use. Direct path was 156 degrees for me, but the actual skewed path worked was about 143 degrees (figure 6). On 10 GHz, Garth was running about 1 watt with a 3-foot dish with no elevation control.

KMØT and WØPUF: Al, WØPUF, in Rapid City, South Dakota had been working on his 10-GHz system for some time, and over the past year we had talked a few times about trying to work each other on 10 GHz. When he got his system up and running, he let me know, and then all we had to do was wait for conditions to pan out.

On July 11, 2004 a really big thunderstorm was present north of the Chamberlin, South Dakota area. I kept an eye on it, as it was not really at the midpoint, but I figured it was worth a try. I called Al, WØPUF, on the phone and he headed out from his home QTH, as he needs to operate in portable mode.

After spending a little bit of time beaconing back and forth, I decided to try pointing a bit north of direct path. I found Al at about 298 degrees, where the direct path would have been 283. He was fairly weak, but I was able to copy just fine on CW. The signal was hashed and "auroral" in nature, as expected. When Al stopped beaconing, I went back to him on CW and we completed the contact.

Right after that we spoke via cell phone and decided to peak the antennas on one another. I did this after the contact, since I did not want to take the chance of losing him altogether if the rain suddenly stopped. We were able to peak the dishes and ended up with 5×5 to 5×9 signals. SSB was readable but pretty weak, as FM was also in there but with a lot of noise.

Al was running 6 watts from a TWT amplifier and his peaked path was 83 degrees, versus 98 degrees for the true path (figure 7). Al was located in DN84jb and the path distance was 573 km (356 miles) to EN13vc, so it was a pretty good haul. It was a new grid for me, and it was Al's first rain-scatter contact and first 10-GHz contact from near his home location (photo E)!

Al kept beaconing for another half hour or so, as I had let both NØDQS and WØGHZ know that Al was sending. However, nothing was heard by the other stations. Al was strong the whole time here, so the conditions were very good. Al was not discouraged, though, as he was really excited about the contact and now knew that Rapid City was on the map for 10 GHz!

More Experiments with 24-GHz Rain Scatter

In late May 2004 I was down in Dennison, Iowa (EN22) for a meeting, which happened to be in the backyard of Gene, NØDQS. I had brought along the 24-GHz dish for some experimenting later that afternoon. Gene and I had been trying some longer paths on 24 GHz in recent months but had little success, so we wanted to "get close" and test the gear again to see if things were working correctly. We did a few close paths, just a few miles apart, and then one at 15 miles. All the equipment was working fine, so we decided to get farther apart.

The next spot at which I arrived was 45 miles away. Gene had his laptop along and gave me the heading after I gave him my GPS six-digit grid square. I then used a KVH Datascope to get a landmark in the distance on the correct bearing. Sure enough, I had chosen a bad location, because off in the distance was a knoll with a farm house and trees. However, the heading was right at a telephone pole on the farm property, and I used that landmark to line up the rifle scope mounted on the dish. Gene was right on heading, albeit weak and just barely copyable on CW, as the obstructions were most likely causing a problem.

We then started to point around for potential rain-scatter paths, as there were lots of clouds with possible rain between and all around us. The day had started off very hot and humid, but it was cooling off quickly and slight sprinkles were coming into the area.

Gene started by elevating his dish while I was transmitting. He got a definite peak at 8 degrees above horizon. In turn, I then elevated my dish, and I also peaked his signal at 8 degrees (photo F). Signals at that point were S7 to S9 and "auroral" in nature. The signals were on direct heading but elevated. We switched to FM and had good communication for about 10 minutes. The rain squall must have been pretty much centered between us, as neither of us could see it.

We then noticed the signals dropping, as whatever was scattering the signals seemed to be going away or moving out of the path. We repeaked and the path appeared to be moving to the east. Elevations were changing, too. Over the next 10 minutes or so the rain squall continued to move. At the time of the best signals I was peaked at 17 degrees above horizon (photo G) and Gene was at 11 degrees. I could then see the squall, as it was closer to me. The signals were full bars on the FT-817 (photo H) and about 30 degrees off direct heading. Dropping the dish to horizon resulted in a total loss of signal, so it was definitely rain scatter. FM was great, and SSB on this

Photo H. The FT-817 (144 MHz IF radio) showing full-strength rain-scatter FM signals at 45 miles.

skewed path was completely unreadable. CW was just like 2-meter aurora!

This was not a serious storm. It was just rain and was an excellent scattering medium. It was also a good test, as our first rain-scatter contact on 24 GHz the year before had been about 70 miles and over a very skewed path. That storm was a *serious* storm. We had no idea that just general rain would be good enough to make a contact on 24 GHz. Incidentally, when we tried the 70-mile path, we were at it for over a half an hour with nothing heard. When we finally decided to elevate the dishes, we found one another in about 5 minutes. We did not have the digital protractors for measuring the elevation at the time, but I would estimate that is was about 5 to 10 degrees. What this confirmed is that elevation for rain scatter on 24 GHz is an important parameter and should not be discounted when trying contacts via rain scatter.

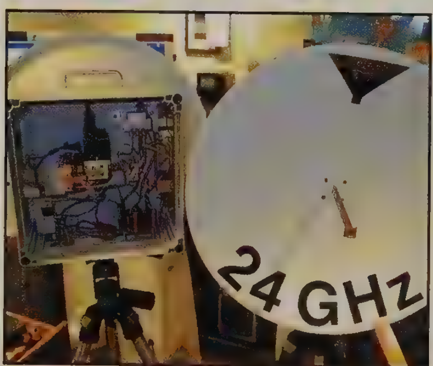
The conclusions are as follows: For 24 GHz, general rain is good. SSB will work on direct-path rain scatter, but not skewed paths to a point. Also, don't be afraid to really elevate the dish, as it probably makes the difference between making a contact or not!

Low power was used most of the time. Switching to high power did little to im-

The Author's Station

KMØT's 24-GHz station consists of a portable 48-cm dish with waveguide-fed splash feed, waveguide switch, and DB6NT transverter. The power amplifier is a solid-state, 2.5-watt unit from W2PED, and all components are mounted behind the dish in a small enclosure. A Lucas AngleStar DP45 digital protractor is mounted on the enclosure to indicate the relative elevation of the dish angle. A riflescope is mounted on top of the enclosure to pick out objects on the horizon for pointing at a specific heading. Heading is determined by using a monocular electronic compass, a KVH Datascope.

The Datascope has a built-in electronic compass with monocular viewfinder to pick out objects in the distance and determine their heading. Mariners use these to determine distance and heading while boating or sailing. The Datascope has 0.1-degree resolution and can be set for east-west declination based on your location in order to obtain true heading (see the KVH website for details). Note that the Datascope is not mounted on the dish, as the metal in the dish and the radio components cause heading errors. All one has to do is pick out an object on the horizon with the Datascope at the correct heading, and then look for that object with the rifle scope mounted on the dish!



KMØT's 24-GHz dishes during final assembly.

See <www.km0t.com> for specific details on the 24-GHz equipment and its design layout. Ten grids have been worked to date on 24 GHz from the KMØT rooftop!

The 5.7- and 10-GHz station at KMØT consists of separate 2-foot dishes with DB6NT transverters and DL2AM solid-state amplifiers mounted in weatherproof enclosures behind the dishes. The 144-MHz IF is located in the shack. The dishes are mounted side by side on a horizontal pipe and utilize elevation control via a Yaesu G-500 elevation rotor.

The whole assembly is mounted on a Wilson MA-40 crank-up mast, which is rotated from the base by an M^2 Orion 2800 rotor. Power on 5.7 and 10 GHz is over 12 watts each at the feed horns. See <www.km0t.com> for specific details on the 5.7- and 10-GHz equipment and its design layout. Currently, 35 grids have been worked on 5.7 GHz and 37 on 10 GHz. →

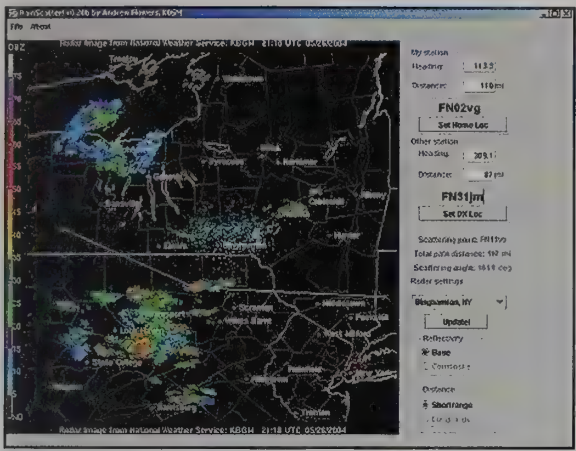


Figure 8. Screen shot from RainScatter.

prove the signals when we were peaked on one another. This is from 2.5 watts on the high side to a 1/2 watt on the low side. For a short time I was listening to Gene as I was getting totally rained upon. There was no real apparent loss of strength, but the signals were pretty garbled! It will take some more practice, but it seems that longer paths are quite possible.

RainScatter by KØSM

A few of the contacts described in this article were aided by "RainScatter," a Java software application developed by Andy Flowers, KØSM (figure 8). Andy came up with the idea while reading about all the recent rain-scatter contacts being made and seeing that folks were having a hard time tracking cells and figuring out headings to the scatter points in real time.

Andy's program simply loads a local NOAA radar map, and when you plug in the six-digit grid square of both stations, it projects a path between the stations and shows the midpoint between them. Then one simply takes the mouse and clicks on the radar map overlay where the cell looks the best for a potential scattering point. With that one click the program then calculates the beam headings to the scattering point for both stations. The program also gives distances and scattering angle and can automatically update the radar map every few minutes if desired!

Be sure to check Andy's website, where RainScatter is available for download as freeware. The link is <http://mail.rochester.edu/~af006m/RainScatter.html>. Andy's program has done wonders for helping make rain-scatter contacts a normal, everyday propagation mode when conditions are there!

In Closing

I hope that this article convinces you that rain scatter is a mode worthy of a try. On 10 GHz it doesn't take much to take advantage of the mode. With a bit of practice, one can make contacts and pick up grids that were hard to get via tropo or were obscured by the local terrain. Download Andy's Rainscatter program and see what it offers. The rainy season will be back in the spring and lots of good DX can be had! 73 and good luck on the bands! ■

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By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Quantifying Our Ignorance

A standard tool of the SETI trade is under constant attack, and although I enjoy a good argument as much as the next ham, it's clear to me that the detractors are clueless as to the very purpose of the tool they so eagerly denigrate. A case in point is a recent critique on the Forbidden Knowledge website (http://www.velocitypress.com/f_knowledge.htm) describing the Drake Equation as "a statistical analysis of the number of possible 'intelligent communicating civilizations' there are in the universe." This summary misses the whole point of a powerful scientific tool that is not really an equation at all in the strictest sense and was never intended for the solving. A brief history of the Drake Equation should help to illuminate its true utility.

The famous Drake Equation, which purports to estimate the number of communicative civilizations in the galaxy, was actually the agenda for the world's first SETI meeting in 1961. This plaque now graces the wall of the room at NRAO Green Bank, West Virginia that once held the blackboard on which the equation was first written. Analysis of the seven Drake factors constitutes a whole chapter in the author's interactive CD-ROM book Tune In The Universe! *published by the American Radio Relay League and available at quality bookstores across this planet (and possibly other planets as well) and through both the ARRL and The SETI League websites.*

The modern search for life in space began just over 40 years ago, when in 1960 Dr. Frank Drake, a young astronomer at the newly established National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia, launched a microwave scan of two nearby, sun-like stars. To no one's surprise, Drake employed the very best ham microwave practices of his day in seeking the ultimate DX. His Project Ozma search came up dry, but demonstrated practical techniques for seeking out intelligently generated signals from space.

A year after Project Ozma's brief tenure, Drake convened the first scientific conference devoted to modern SETI at Green Bank. The handful of scientists who assembled there called themselves the Order of the Dolphin, choosing recent studies of human-dolphin communication as a worthy metaphor for the challenge of interspecies communications on a grander cosmic scale.

On a blackboard, for discussion Drake chalked seven topics that would comprise the agenda for the week-long meeting. They included stellar formation, planetary formation, the existence of habitable zones, the emergence of life, the evolution of intelligence, communications technology, and the longevity of technological civilizations. Then Drake did something almost whimsical, something which assured his lasting fame: He strung together these seven factors into an equation.

The idea was to multiply seven unknowns together, and in so doing, to estimate *N*, the number of communicative civilizations in our Milky Way galaxy. The Drake Equation, as it is now called, appears in every modern astronomy textbook. It is a marvelous tool for quantifying our ignorance. It was never intended for quantification, but is quite useful in narrowing the search parameters. We still use it, not to seek a solution, but rather to help us in designing our searches for life.

Drake's seven factors are cleverly ordered, from solid to speculative. Today's astrobiology meetings are similarly sequenced. When first published, only the first factor (the rate of stellar formation) was known to any degree of certainty. In the intervening decades, the Drake Equation has guided our research in an orderly manner, from left to right, so that today we have a pretty good handle on Drake Factors two and three (planetary formation and habitable zones). The remaining four factors are still anybody's guess, and it may well take decades more before our research begins to quantify those areas of our ignorance. However, the Drake Equation is most valuable in guiding our research, because it asks the important questions. It is still up to us to answer them.

Although the Drake Equation detractors miss the mark with regard to the intent of the tool, they do raise a valid point that is central to astrobiology: How can life, the chance result of a painfully long chain of highly improbably events, possibly have evolved elsewhere? One testable hypoth-

(Continued on page 76)

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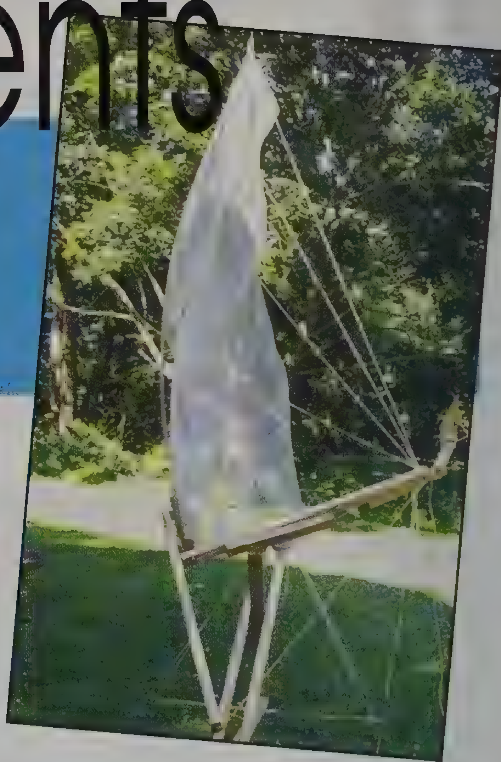
Printed in the United States of America.
Postmaster: Please send change of address to CQ VHF Magazine, 25 Newbridge Road, Hicksville, NY 11801.

contents



Spring 2005
Vol. 8 No. 1

FEATURES

COLUMNS

DEPARTMENTS

On The Cover: Homing in on hidden transmitters is an excellent way to introduce youth to the fun of our hobby. Here Andy Bradford has homed in on "the fox." For details see p. 42. Inset photo: Have you tried 47 GHz yet? In his "Microwave" column, WB6IGP gives information on how to do it (see p. 63).

CQ VHF Ham Radio Above 50 MHz

LINE OF SIGHT

A Message from the Editor

Oklahoma City Ten Years Later

It was on April 19, 1995 that this country suffered the worst terrorist attack in its history up until that time. From the very beginning of the aftermath of the Oklahoma City bombing amateur radio was involved. In particular, VHF and above frequencies proved to be the workhorse bands for the huge volume of traffic coming out of the perimeter of the bombsite.

In so many ways amateur radio shone. At the time of the blast, I was the ARRL Section Manager for Oklahoma. It became my responsibility to oversee the deployment of the amateur radio volunteers. It was truly amazing to see the outpouring of volunteers who provided the emergency communications during the nearly three weeks following the disaster. In all, more than 300 hams volunteered their time and equipment for the duration of the operation. My work was made so much easier than it could have been thanks to the ongoing training exercises conducted by local ARES volunteers who worked alongside the Salvation Army's network of amateur radio operators.

Almost from the beginning of the disaster rescue and recovery operations, the critical need for amateur radio involvement became apparent. Immediately following the bombing, cell-phone usage became almost impossible as more and more people used their cell phones to attempt to make calls, thereby jamming the various repeaters on the several networks in the Oklahoma City area. Without cell phones, amateur radio became the primary mode of communications. Hams were stationed at all of the area hospitals, at strategic points within the disaster perimeter, and at key locations throughout the city.

Initially, I was in the Oklahoma City police van providing information to the police as to the whereabouts of the various non-government organizations operating within the perimeter. Later I was assigned to provide communications for a Salvation Army canteen located across the street from the bombsite.

Local repeaters were pressed into constant 24-hour service, which was far in excess of their recommended duty cycles. In spite of this demand, these repeaters continued to perform admirably.

It's been ten years since that horrible Wednesday morning in the middle of April. I wish I could say that what we experienced in Oklahoma was the end of terrible terrorist disasters. However, it's just the opposite. It was the beginning. In the aftermath of the Oklahoma City bombing we still were naïve. We thought that we could do some debriefing for our own hobby interest, never thinking that we would ever be pressed into service with such intensity again.

As we all know, however, on September 11, 2001 we learned that Oklahoma City was but a blip on that radar screen focused on terrorism. What we learned from Oklahoma City proved to be very important. Even so, in the aftermath of September 11th, we found that we had so much more to learn. Thankfully, amateur radio seems to have become an integral part of the fabric of what is now known as Homeland Security.

My wife, Carol, W6CL, and I—and I am sure the vast majority of amateur radio operators who volunteered in the aftermath of the Oklahoma City bombing—will forever have vivid memories of the event. We wish that we could erase them. However, that is not the way with us humans. We who want to work for the good try to make good come out of those memories. One way to do this is to learn more about how we can be of service via our hobby.

New In This Issue

One way that we can learn how we can be of service is by way of reading about others' experiences. With this spring issue of *CQ VHF* we introduce a new column entitled "VHF+ Public Service." Edited by April Moell, WA6OPS (wife of Joe Moell, KØOV, the "Homing In" column editor), the column will cover her more than two decades of public service to our hobby, as well as current events that have a VHF tie-in. We look forward to reading about and learning from her and others who share their experiences with her as the column editor.

Another education source that is new with this issue is entitled "VHF+ Beginner's Guide." Edited by Rich Arland, K7SZ, it will cover basic concepts in VHF communications. For more than 30 years Rich has been writing for amateur radio and radio hobby publications, such as *CQ, QST, Monitoring Times, The Milliwatt,* and *WorldRadio.* Rich will continue to write the "Homeland Security" column for our sister publication, *Popular Communications.*

Also In This Issue

I am one who believes that education is always occurring. An excellent example of this is in this issue's "Homing In" column. As you can see by the cover photo, Joe Moell, KØOV, is making sure that youth are involved in hidden transmitter hunting, which is certainly one great way to introduce youth to our hobby and educate them at the same time. I would like to see articles from you, the readers, that tell of experiences of education in your local schools and how ham radio is being used as a vehicle to promote education of our youth. Speaking of hidden transmitter hunting, in this issue Gordon West, WB6NOA, writes about a new device that makes it much easier to locate the fox.

Other articles in this issue include the following: Continuing with his technical excellence, Leif Asbrink, SM5BSZ, presents part one of another two-part article, this one focused on transmitter quality. Al Katz, K2UYH, writes about an easy-to-construct portable dish antenna for 1296 MHz. Jon Jones, NØJK, covers unusual sporadic-*E* propagation. Ken Neubeck, WB2AMU, writes about conquering the January VHF Sweepstakes Contest from his automobile.

Saying Goodbye

As you will read in the "FM" column, Gary Pearce, KN4AQ, has written his last column for *CQ VHF*. Gary put off starting a magazine for the audio/visual field for quite some time, and he has decided that he needs to shift his priorities to that magazine. Gary has been with *CQ VHF* since its restart three years ago. Gary, we thank you very much for your hard work on the column and we will miss you a lot.

With Gary's departure, we are looking for a replacement columnist who will cover the technical side of FM and repeater operations. Please contact me at <n6cl@sbcglobal.net> if you are interested.

See You At Dayton

Carol and I will be at the VHF banquet the Friday night of this year's Dayton Hamvention®. Also, I am slated to give a talk at the VHF forum on Saturday. We look forward to seeing you at the CQ Communications booth or somewhere else during the Hamvention®.

73, de Joe, N6CL

The "Minor" Spring Equinox Sporadic-E Season of 2005

Winter sporadic-*E* usually occurs in December and January. Here NØJK describes very rare late-winter openings that occurred this year.

By Jon Jones,* NØJK

*"Sporadic-*E *(Es) occurrences are very rare during the months of September, October, February, and March, regardless of the zone. The spring equinox is the lower of the two."*
—VHF Propagation, A Practical Guide for Radio Amateurs *(Neubeck, West)*

"Probably the most March VHF Es *that I've seen in 40+ years of this." Pat Dyer, WA5IYX. Post to "Magic Band" Internet chat room March 09, 2005.*

The "spring equinox" 2005 *Es* season may well be one of the best ever recorded. Beginning on February 10th, the 6-meter band was open for *Es* on the 10th, 12th, 13th, 18th, 19th, 20th, 21st, 22nd, 23rd, and 25th. Ten out of fifteen days! The bands took a rest for a few days, then *Es* reappeared daily starting on February 28th and March 1st, 2nd, and the 3rd. Another break, then *Es* again on the 6th, and culminating in a massive 12-hour *Es* opening with TEP (trans-equatorial propagation) links to South America March 9–10.

The minor equinox season started with little hint of what was to come. The first week of February was a slow one for stateside stations, with some weak aurora reported on the 7th by stations in W1 and W7 along the northern tier states. To the south in Central America, the Caribbean, and South America, the TEP season was in full swing. ZP6CW in Paraguay reported FM, 9Y, P4, etc., on February 9th. Some weak aurora was heard on the evening of the 9th. Then on February 10th, *Es* appeared. A 3-hour long *Es* opening was reported along the eastern seaboard between W1, W3, W4 to Florida and Texas.

*8949 Churchill Ct., Wichita, KS 67206
e-mail: <n0jk@hotmail.com>

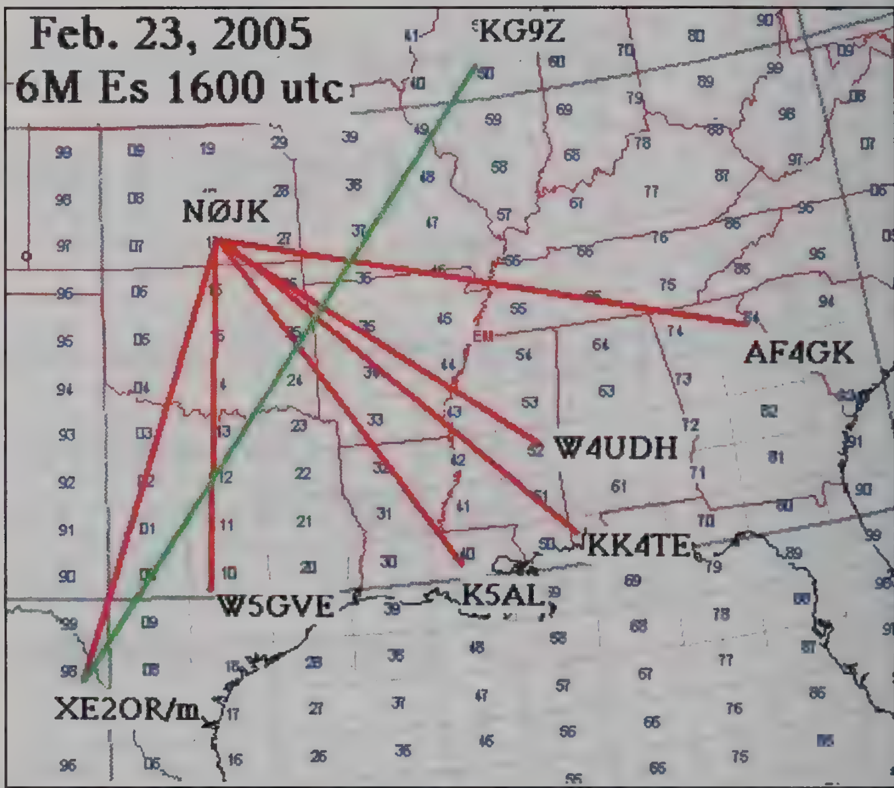


Figure 1. On 23 February 2005, NØJK in EM17 worked Rafael, XE2OR/m in DL98 on 50.125 MHz.

On the 12th there were more *Es* occurrences from W1 to W4 and W5 along the Gulf Coast starting at 0040 UTC. As the *Es* opening in the east faded, a secondary *Es* center appeared in the west. Stations in Texas worked Arizona and California for a couple of hours to 0500 UTC. *Es* appeared again in the same day, starting at 1400 UTC between Illinois and Florida. On the evening of the 12th (now February 13 UTC) there were many *Es* contacts reported on 6 meters across the desert southwest between Arizona, Nevada, and California. The daily series of *Es* openings then stopped. Had this been it for February *Es*, it would have been an above-average month. The following are a series of observations that were made by myself, along with additional information from the various 6-meter spotting sites on the Internet. All dates and times are in UTC.

February 18th: Picking Up the Action

A geomagnetic disturbance began on February 17th, and aurora QSOs were reported on 6 and 2 meters on both the 17th and 18th UTC. The morning of February 18th, the spring 2005 equinox *Es* action really picked up. Starting early at 1200 UTC, a loud and widespread *Es*

opening occurred over the eastern states. The *Es* waned at 1500 UTC, but then picked up to the west. In Wichita I worked W7RV and K7TOP in Arizona (in grid DM43) with loud, steady signals at 1540 UTC. This was a "summer"-type *Es* opening, not the weak "popcorn"-type *Es* usually encountered in February. The *Es* opening moved west, with K6QXY reporting the W5RP beacon at 1830 UTC. This opening lasted over six hours! In the afternoon there were more Es openings, with WB5KIA and AB5K in Texas and K5UIC in Louisiana working XE1AY (DK79) in Mexico at 2230 UTC.

"Some major Es *events on 6 meters have occurred on rare occasion during the equinox months and usually catch hams by surprise."* – VHF Propagation, A Practical Guide for Radio Amateurs *(Neubeck, West)*

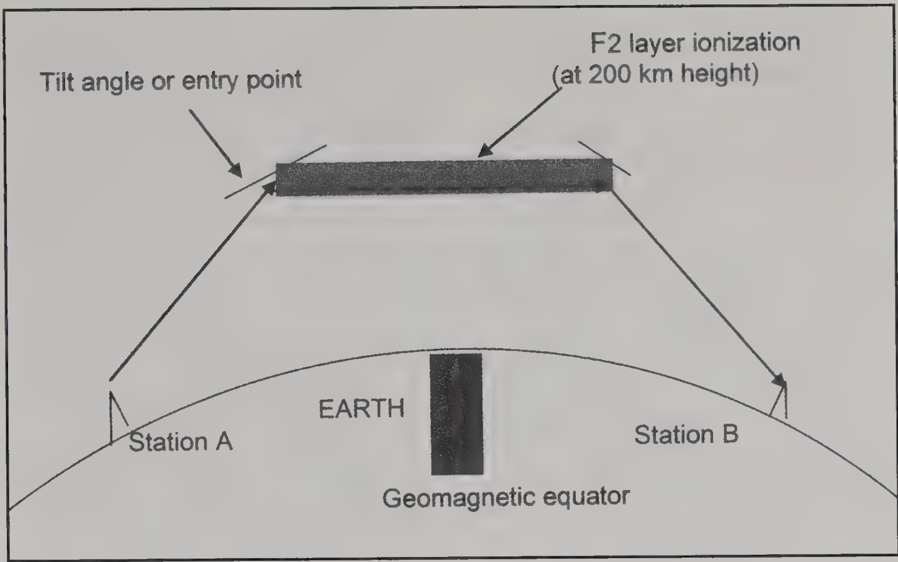


Figure 2. Transequatorial propagation (TEP) appears primarily on 6 meters and on rare occasion on 2 meters in certain parts of the world. (Figure courtesy of Ken Neubeck, WB2AMU)

February 19th: XE2YW DL82, XE2HWB DL44, XE1MEX EK08

Was the *Es* opening on the 18th a one-time event? The next day proved it was not. Starting at 2100 UTC on February 19th, stations in Texas began hearing the W4CHA beacon in grid EL88 Florida. The *Es* opening spread to cover much of the eastern part of the country, with the Gulf Coast in the thick of it. Conditions were good enough on 6 meters for QRP stations to make solid contacts. For example: 50.160 MHz, 2233 UTC, 19 Feb. 2005, N3CR (FN20) works K9HUY (EL86); N3CR uses 10 watts and a quad.

At 2250 UTC, from my QTH in Kansas (grid EM17), I worked XE2YW DL82 on 50.125 MHz. Stations in Oklahoma and Texas also worked Eduardo for a rare new grid, such as: 50.125 MHz, 2254 UTC, 19 Feb. 2005, KD5VHZ (EM15) works XE2YW (DL82).

Bernardo, XE2HWB, DL44 La Paz, Mexico worked into Texas: 50.125 MHz, 2307 UTC, 19 Feb. 2005, WB5KIA (EM13) works XE2HWB (DL44).

At 0134 UTC February 20th Pat, W5OZI, worked XE1MEX (EK08), and 20 minutes later Lefty, K1TOL (FN44), heard the C6AFP/b. Would the *Es* "link up" to TEP on to South America? Not this evening. Single- and double-hop *Es* to the south can sometimes form a "link" on to the trans-equatorial propagation to South America and the South Pacific.

The February 18th and 19th *Es* openings caught many 6-meter operators "by surprise." Who thought there would be any *Es* in late February on the 6-meter band? Word spread quickly on the "prop loggers" and Internet VHF chat rooms such as "DXers.info" that something was up with 6 meters.

February 20th/21st: "Big Ole Summertime" 6-meter *Es* opening

Es reappeared on the 20th, and this time 6-meter operators were ready. The 6-meter band popped open at 1915 UTC between Florida and Texas, with K4RX EM70 working WB5KIA EM13. The *Es* opening grew rapidly over the next hour, and 50-MHz spots scrolled by quickly on the packet clusters. The *Es* opening appeared to involve the whole eastern part of the United States, west to the Colorado border. W1, W2, W3, W4, W5, W8, W9, and WØ call areas were spotted. This was a strong, loud, and steady opening. Occurring on a Sunday, many hams were at home and able to get on the radio. Heard on the band were comments such as "This is just like a June opening." Many mobile stations were getting 59+ reports—e.g., 50.125 MHz, 2211 UTC, 20 Feb. 2005, K4YYL (EM84) works NØJK/M (EM17).

Stations with wire antennas got out like big guns: 50.128 MHz, 2332 UTC, 20 Feb. 2005, N8CJK (EN84) works AG4YO (EM60); AG4YO gets 5/9 report using wire dipole.

The opening went on hour after hour, well into UTC February 21st. Hundreds of 6-meter QSOs were made. By 0350 UTC the *Es* reached Colorado, with KØGU (DN70) hearing the K5AB beacon in grid EM01. The opening was fading for the more easterly stations, though. This was a six-hour long opening for many stations. However, despite some short 6-meter *Es* QSOs—such as AC4TO (EM70) to K5UIC (EM32) at 2008 UTC —no 2-meter *Es* contacts were reported. Also, there were no *Es* links to South America. This may well have been one of the best February 6-meter *Es* openings ever. On February 20, 1996, Ken, WB2AMU, observed a two-hour 6-meter *Es* opening. He considered this to be an unusual opening. Again on February 20, 2001 Ken observed 6-meter *Es* lasting for about three hours in the morning. The February 20, 2005 *Es* opening was over three times as long! Is there something about February 20th and *Es*? Ken wrote that there was a second three-hour *Es* opening that evening, resembling the diurnal summertime *Es* openings. The 2005 event was over six solid hours, starting in mid-afternoon.

What a great day February 20/21 UTC, 2005 was for 6-meter enthusiasts. Many wondered what the next day would bring.

February 21st was a slow one on 6 meters. In the evening (February 22nd UTC) some *Es* openings were reported on 50 MHz by Lance, W7GJ, in Montana to Oklahoma City at around 0150 UTC. AC7XP (DM43) in Arizona worked N7DB (CN85) in Oregon at 0356 UTC. That afternoon VE1YX (FN74) worked KG9Z (EN50), K9FW (EN71), and oth-

ers at around 2000 UTC. Thus, the string of daily February 6-meter *Es* openings remained unbroken.

February 23rd: *Es* Diurnal, XE2OR/m Goes Roving

As the daily *Es* continued in February, something interesting began to happen. The "summertime diurnal" *Es* pattern (morning and evening *Es*) occurred. On the evening of February 22nd local (February 23rd UTC) there was a nice 6-meter *Es* opening between Texas and Louisiana to Kansas and Minnesota. Leon, WB5NRI (EM22), was loud to Wichita at around 0225 UTC. Leon is only 375 miles from Wichita, a short *Es* hop, implying a high MUF (maximum usable frequency). A second *Es* center formed over Kentucky, and KA6AKH (FM18) worked stations in EM37 and K5SW (EM25). The next morning, following the "diurnal" *Es* pattern, the 6-meter band was again open via *Es* to Texas, Louisiana, and Mexico starting at 1530 UTC. The *Es* was open over some of the same paths as the previous evening—another feature of summertime *Es* openings. I had nice chats with KK4TE (EM50), Smitty W4UDH (EM52), K5AL (EM40), N5QK (EM40), and W5GVE (EM10) in Texas. At 1600 UTC Rafael, XE2OR (DL98), popped up on 50.125 MHz running mobile. Rafael quickly drew a crowd: 50.125 MHz, 1613 UTC, 23 February 2005, NØJK (EM17) works XE2OR/m (DL98, see figure 1)—a big pile-up!

It took a few calls, but I was finally able to break the pile-up and work Rafael. He said he would drive to EL08 and some other rare grids and hand them out if the band stayed open. By the time he got to EL08 the band had dropped from Kansas, but Rafael was able to give EL08 to a couple of EN71 stations. The *Es* continued for about another hour as stations in Texas worked into Kentucky and Alabama. Ken, WB2AMU, notes in *Six Meters, A Guide to the Magic Band,* "…one could easily be as popular as a 3Y5 or a 3W8 DX station by operating in a rare grid such as DL88 or EL79."

February 24th saw no *Es* reported on the clusters or loggers. However, 6 meters was hopping in other parts of the world. The TEP season was going strong, and Eric, FM5JC, reported working 5T5SN for a new country at 0024 UTC on the 24th. If there had been double-hop *Es* from the Midwest, could it have linked on to 5T?

February 25th was another slow day. N8UUP reported hearing WA4VUT (EM50) "via weak *Es*" at 0220 UTC. Therefore, February 25th can be logged as another day of 6-meter *Es* for the 2005 season. February 26th and 27th had no Es either heard or worked. Some wondered if this was the end of the minor *Es* season. After all, March was almost here.

February 28th

To the surprise and then relief of 6-meter operators, *Es* appeared again on February 28th. Graham, KE4WBO (EL96), in south Florida had a strong opening to St. Louis, Missouri around 0045 UTC. Dennis, K7BV/1 (FN31), reported K4OXG (EL98) loud at 0202 UTC. Continuing the "diurnal" theme, the *Es* reappeared the next morning and afternoon. N3ALN (FM19) had K4OXG (EL98) back loud at 1656 UTC. The opening continued with some DX showing up. KB1KHK worked C6ANM on 50125.0 at 1814 UTC. Ed, VP9GE (FM72), in Bermuda worked W4MYA, K8WK, and others at around 1830 UTC. The *Es* opening picked up in the afternoon along the east coast. More DX was worked as K4CIA (FM05) spotted NP3CW (FK68) at 2205 UTC. FM5JC spotted ZD8VHF/b at 2302 UTC, but I noted no stateside spots for this beacon. The opening expanded west with K5BZM (EM18) working K4YMQ (EM63) at 2332 UTC. *Es* continued on to 2359 UTC.

There had now been six days in a row of *Es* on 6 meters in late February—a great "minor" *Es* season. Would it continue on into March?

March 1st: *Es* Appears!

Yes, it did! I worked Ivars, KC4PX (EL98), with a "40 over S-9" signal at 0046 UTC 01 March! The *Es* continued to Florida until 0300 UTC. Chalk up three hours of *Es* for March 2005.

March 2: March Madness—*Es* Links to South America

The next afternoon *Es* "appeared like clockwork" starting at 2314 UTC with

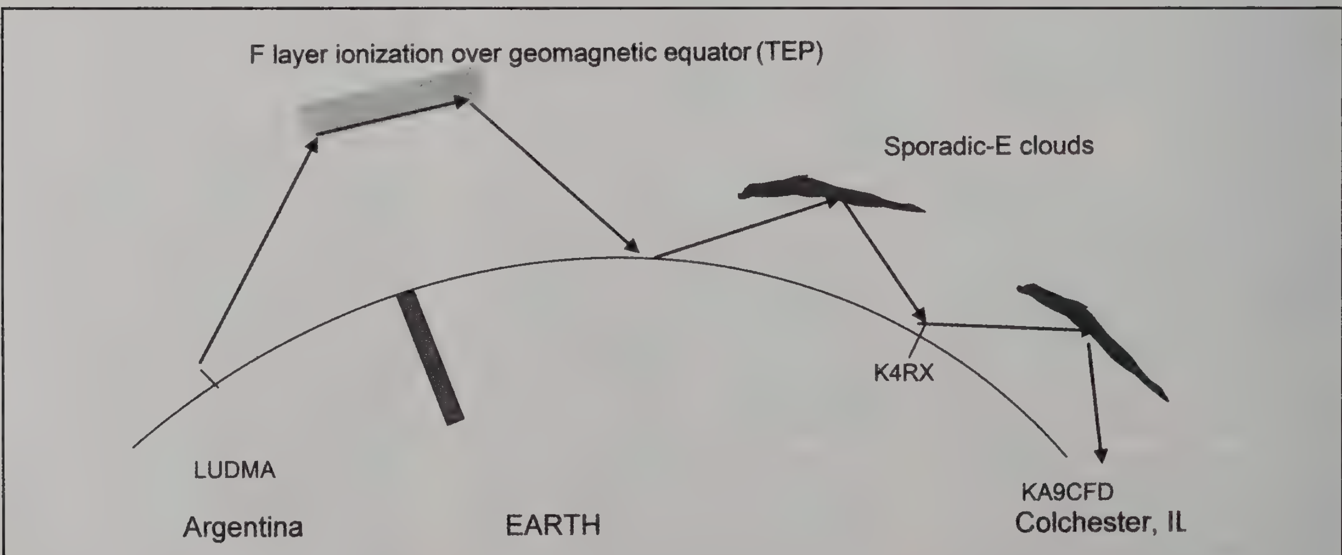


Figure 3. Combination TEP and Es *opening from the Midwest U.S. into Argentina on 6 meters on March 2, 2005. (Figure courtesy of WB2AMU and adapted by NØJK)*

K4RX spotting NP3CW, and K4DD (EM60) spotted the new 6Y5RC beacon 50.025 MHz in Jamaica. K4RX also spotted "CE/Musica" at this time, and Doug, ZP6CW, spotted 9Y4AT/b via TEP. The northern boundary of the TEP zone was likely the southern Caribbean and northern South America. The *Es* spot by K4DD clearly indicated the potential for an *Es* link on to South America via TEP. Indeed, at 2344 UTC ZP6CW spotted K4RX on 50.110 MHz. At 0012 UTC on March 2nd KA9CFD (EN40) worked LU1DMA (GF05)! What an amazing contact, five years from the peak of solar Cycle 23. At 0105 UTC I heard LU1DMA on 50.110 MHz! This may have been multi-hop *Es* linking to TEP propagation. See figure 3 for a graphical representation of this path.

Double-hop *Es* linking to *F2* and TEP has been documented previously. I personally made double-hop *Es* to *F2* QSOs on April 30, 2003. That afternoon had double-hop *Es* from Kansas to Costa Rica, with Keko, TI5KD, very loud on 6 meters. At the same time, the double-hop *Es* linked on to *F2* to LU7WW in Argentina at 1918 UTC.

I also heard HI3TEJ on March 2nd. Ted, HI3TEJ, was working W4 and W5 by loading up an 80-meter Zepp antenna on 6 meters! HI8ROX showed up on 50.120 MHz at around 0215 UTC. Unfortunately, I have a loud cable TV spur on .120 and was unable to copy Rafael very well. Bud, WØEKZ (EM17), did exchange 5 by 5 reports with HI8ROX at this time. This was double-hop *Es,* with the first hop from Kansas landing in the Florida panhandle, then the second hop on to the Dominican Republic. I believe KA9CFD may have had double-hop *Es* to the TEP zone, with the Florida panhandle stations having single-hop *Es* to TEP. By plotting W2GFF's logging, one can see there was an *Es* cloud for K4RX to LU. There were *Es* clouds for the hop from Florida to Illinois. The reports from Florida of the Dominican Republic stations and the Jamaican 6Y5RC beacon spots showed the presence of widespread *Es* clouds south of Florida on March 2nd. The 6Y5RC beacon spots are critical in

(Continued on page 70)

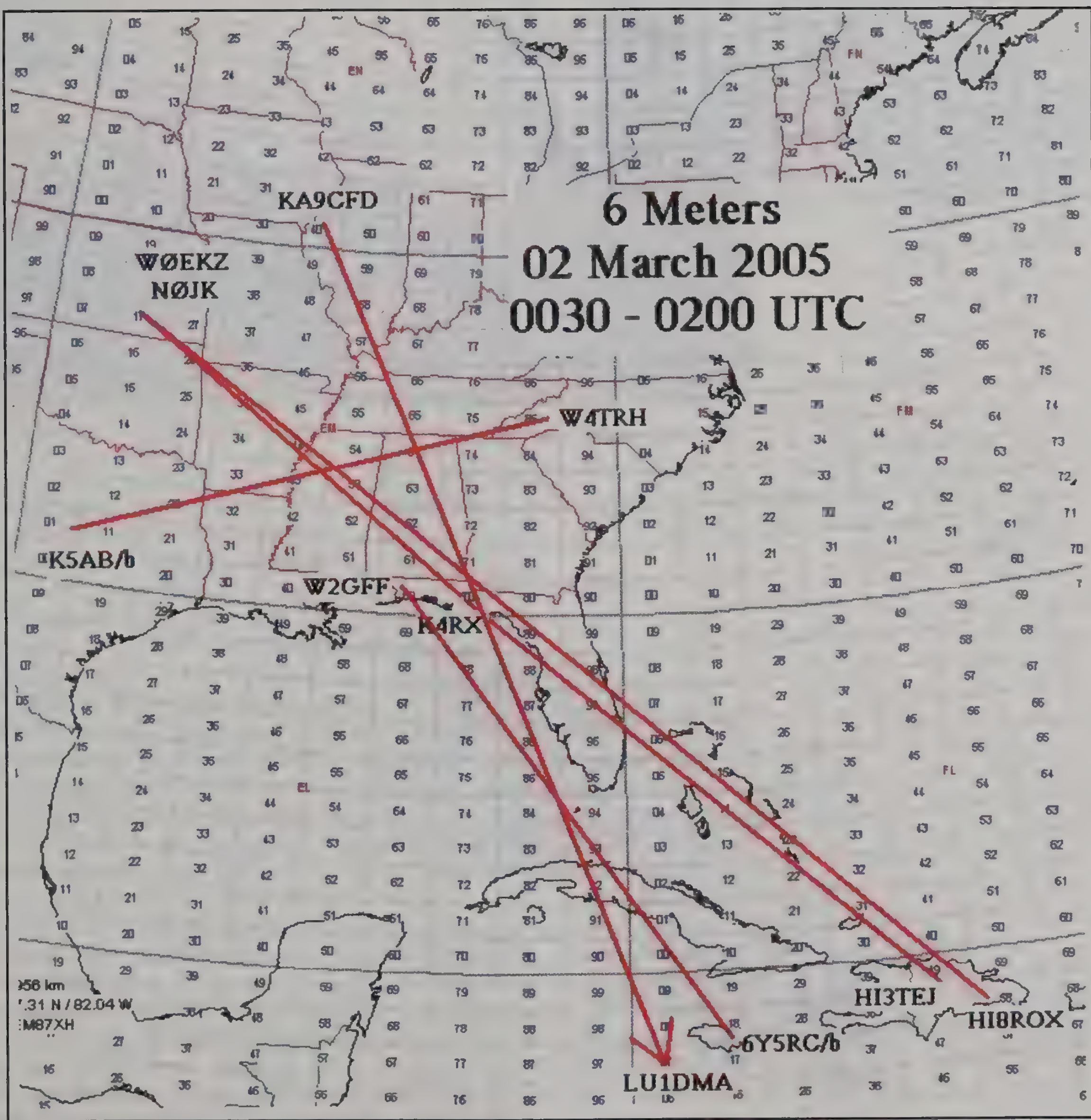


Figure 4. This map of the paths on 6 meters on March shows the value of posting loggings, even if it is not for "DX." Six-meter operators can plot the Es *paths and see if a path may be open.*

Field Testing
The Australian Foxhunt Sniffer

Thanks to Aussie VK3YNG, the fox has to be even more clever on future hidden transmitter hunts. In this article WB6NOA describes the latest device for finding the fox.

By Gordon West,* WB6NOA

Every January over a thousand hams head for Quartzsite, Arizona to play radio for a full week. They are RVers. The gathering includes hundreds of thousands of non-ham RVers as well, but the ham attendees have their own activities, called Quartzfest.

Each day the hams come together for their morning briefing on the specific radio "exercises" for mid-morning and mid-afternoon. One morning during the 2004 event there were hams running all over the desert looking for geocachs, presented by Frank, WB7DRB, and Charlou, KE6KNO. The geocaching team had placed ham radio trinkets out in the desert, and hams with GPS receivers became so good at working the coordinates that they could get right down to the bush where the geocach was hidden. Of course, all of this was coordinated on the 2-meter band.

Foxhunting was next on the agenda, hosted by Bill Pienups, WT7Z. Bill and his team had hidden two low-power, sequenced transmitters about two miles away, camouflaged by sagebrush.

Foxhunters came with the usual array of finders: L-tronics locators, three-element beams, elaborate shielded scanners with series RF attenuation, and common HTs for body-shielding techniques. My receiver was the brand-new Foxhunt Sniffer from Bryan Ackerly, VK3YNG. The Sniffer was fresh out of the box. I had never used this equipment before, but I had seen it in action with my pal Jim Ford, N6JF, and also in use at a KØOV session a few months before. I was told by Foxhunt experts that this receiver makes finding hidden transmitters fun and easy.

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Quartzsite hams enjoying the foxhunt. (Photos by the author)

The Sniffer

The Australian Sniffer is a fully self-contained receiver, audio amp, PLL synthesized for 143–150 MHz, plus PLL synthesized to cover 120–123 MHz ELT (Emergency Locator Transmitter) frequencies. It has a built-in speaker and also a daylight-viewable *bright* digital display of operating parameters—most notably signal strength—which clearly let you know when you are right on top of the hidden transmitter.

This most amazing receiver has plenty of sensitivity to hear even the faintest of signals barely detectable on your trusty 2-meter HT. Also, as you get closer to the signal source, the built-in receiver *automatically* steps in 15 dB of attenuation, *automatically* selecting the optimum signal level with accompanying signal-strength readout as you look for the transmitter. A value of 9 on the bright readout indicates you are absolutely on top of the transmitter with 135 dB of attenuation. Zero on the display typically is nothing but background noise, with the receiver as sensitive as a half microvolt.

Signal-strength levels are provided by an audible tone that increases in frequency pitch as the signal level increases. When you begin the hunt, the pitch slowly rises as you head in the direction of the signal source. As the pitch rises to nearly a high squeak, the Australian Sniffer *automatically* registers one number higher on the display with the recalibrated pitch down low. As you get closer, the pitch climbs again, and when you are back at the high squeak, one number higher appears on the display as the pitch starts low again. *You don't need to push any buttons as you get closer to the signal source!*

Quartzfest would test how effective this automatic circuitry is. I planned to use the common three-element Arrow antenna for signal directionality. Body shielding with just a rubber duck could

also be used, and as we were mobile, hooking into an outside antenna would give us a clear indication of whether we were heading toward the transmitter or away from it!

When you open up the back of the case to add two alkaline, long-life batteries, you can marvel at all the circuitry Bryan Ackerly has stuffed into this tiny box. Power up the unit and then prepare to enter your specific T-hunt frequency. Buttons 1 through 6 allow storing and recalling memory modes and frequencies, with some frequencies already memorized. I would write in 146.565 as the T-hunt channel. The display will show the last four digits of the selected memory frequency in kilohertz. Pressing and holding the buttons will result in the selected frequency and mode being stored in the selected memory, 1 through 6. The button must be pressed and held until two short beeps are heard in succession. This confirms that the frequency has been entered in memory.

Modes? Modes available are AM reception (A), FM open squelch (U), FM with squelch (F), and signal-strength tone, which reads out on the display. For the advanced T-hunter, headphones may be used where one channel is set to give signal-strength tone and the other channel follows the natural-sounding selected mode. This is useful for hunting different continuous-carrier transmissions where the transmitter's identification is given using either AM or FM modulation. Without headphones, the built-in speaker plays a myriad of low-level whistles as the unit looks around for a signal.

VK3YNG's Foxhunt Sniffer is compact and can also be operated with a rubber-duck antenna!

The Quartzfest Hunt

When the hidden transmitters became active on the desert floor, my Sniffer, hooked into the three-element beam, instantly came alive with a signal-strength reading of 1. A quick sweep with the Arrow antenna gave me an unmistakable rise in pitch when the antenna was pointed toward one of the hidden Ts. A minute later, one T went off and another came on, and a quick swing of the three-element antenna gave me a crystal-clear indication that the *other* hidden transmitter was located much closer than the first one (higher number on my display) and 45 degrees east of the first signal. Since this transmitter was closer, yet in the same general direction, we decided to go after it first.

Finding the first transmitter was a snap with the Sniffer. As we drove down a desert road, we used a rubber-duck antenna on the Sniffer inside the vehicle and continuously watched the signal strength go higher. This corresponded with the tone pitch as it went from low to high as we got closer to the signal. But wait . . . the tone was then going down. We hit the brakes, climbed out of the vehicle, put the three-element beam on the Sniffer, and saw that we had to be extremely close to the hidden transmitter, because the signal-strength digital readout was showing 6. This was a 50-milliwatt transmitter, so we simply walked in the direction of the ascending tone and literally went in a straight line right down to the desert bush in which the transmitter was hiding. It was well hidden! We actually had to dig in the sagebrush to finally spot it.

We got to the transmitter just as it was cycling down for the next minute of the other transmitter. A quick sweep with the beam confirmed it would be on the other side of the road and still pretty far away, because signal strength had barely gone from 1 to 2 on the display.

Off we went with the rubber duck back on the Sniffer. When the display went to 4 and then began to drop in pitch, we hit the brakes and backed up 100 yards to a dirt road leading to nowhere imaginable out in the desert. Out of the car we jumped and added the beam, and sure enough, down the road and a little bit to the right we went. And as we walked down the road, the tone began to get noticeably higher in pitch, and this confirmed we were headed in the right direction and getting relatively close to the hidden transmitter. With only 3 showing on the display, we continued to walk in the same direction, even though the original transmitter, T #1, was playing its tune miles away.

After 10 minutes of walking with the display numbers flashing between 6 and 7, we knew we were getting close. The beam clearly gave us a peak in pitch in the direction of a large desert cactus. When we got as close as we could, we walked all around the cactus with the beam continuously pointed at the cactus. There it was, nestled in a tiny crevice of the cactus—hidden T #2.

Advanced Features of the Sniffer

For the more experienced T-hunter reading this article and yawning while thinking that the transmitter hunt was too easy, there are plenty of advanced features in the Australian Foxhunt Sniffer. Version 2.2 or later has a special mode for hunting very-short-duration pulsed or "PIP"-like sounding transmitters. This type of signal may only be 40 milliseconds, but it is plenty long enough for the receiver to track it. Pulsed 40-millisecond signals can be used for tracking animals, model rockets, and model planes.

The Sniffer has a peak extend mode which stretches out the received pulse so that its signal level and resultant tone can easily be determined by rapidly swinging the beam. We also found this mode useful in identifying noise sources found in motorhomes and motor yachts. We could actually pinpoint the

(Continued on page 74)

A Small Offset Stress Dish for a Portable 1296-MHz EME Station

Originally published in the *Proceedings* of the 11th International EME Conference (August 6–8, 2004), this article describes an offset dish and mount that was designed for portable EME operation on 23 cm. The antenna and mount can be disassembled into a relatively small, lightweight package that can be carried as luggage on an airplane, yet is equivalent in performance to an about 8-foot diameter parabolic dish.

By Al Katz,* K2UYH

The development of JT44/65 software has generated considerable interest in portable and mini DXpedition activity on 1296-MHz EME.[1,2,3] Most of these DXpedition stations have used single long Yagi antennas because of their small size and low weight. Unfortunately, on 1296 MHz single Yagis have insufficient gain to allow CW contacts with all but the largest stations. CW remains the preferred, if not the exclusive, mode of many EME operators. Even using JT44/65, QSOs are not possible with the smaller 1296-MHz stations. Consequently, a small but higher gain antenna should be of great interest for portable 23-cm EME operation.

One problem with Yagi antennas is that most are linearly polarized, while almost all *regular* 23-cm EME stations use circular polarization. It is possible to produce a circularly polarized Yagi, and this would help. The use of circular polarization would provide an effective gain increase of 3 dB, but even more gain is desirable.

Dish antennas can be fed circularly polarized and provide lots of gain, but they also provide considerable additional weight and size, along with the gain. Stress-dish designs can solve the problem of weight. For small-size dishes feed blockage becomes a problem. At 1296 MHz, particularly for dish diameters of 8 feet and less, feed blockage starts to significantly reduce antenna efficiency. The offset dish concept eliminates the feed-blockage problem. It allows relatively small dishes to provide high-gain efficiency. It thus seems that a circularly fed, offset stress dish would be an ideal antenna for portable 1296-MHz EME operation. This article describes the design of just such an antenna.

Photo A. A 7.5-foot offset dish on polar mount. (All photos courtesy of the author)

Offset Dishes

Offset dishes are just a portion of a parabola of revolution (conventional parabolic dish).[4] The antenna described in this article uses slightly less than a quarter of a conventional dish reflector. By using only part of a normal *full* dish as the reflector, the feed antenna can be moved away from the center of the reflector, where most of the RF energy is located. The feed can be located to one side of the reflector, where little or no RF energy is present, as shown in figure 1. The feed must still be located at the focal point of the parabolic curve. The feed must also have higher gain, since it *ideally* should only illuminate the reflector area. (As noted, the offset dish is only a *fraction*

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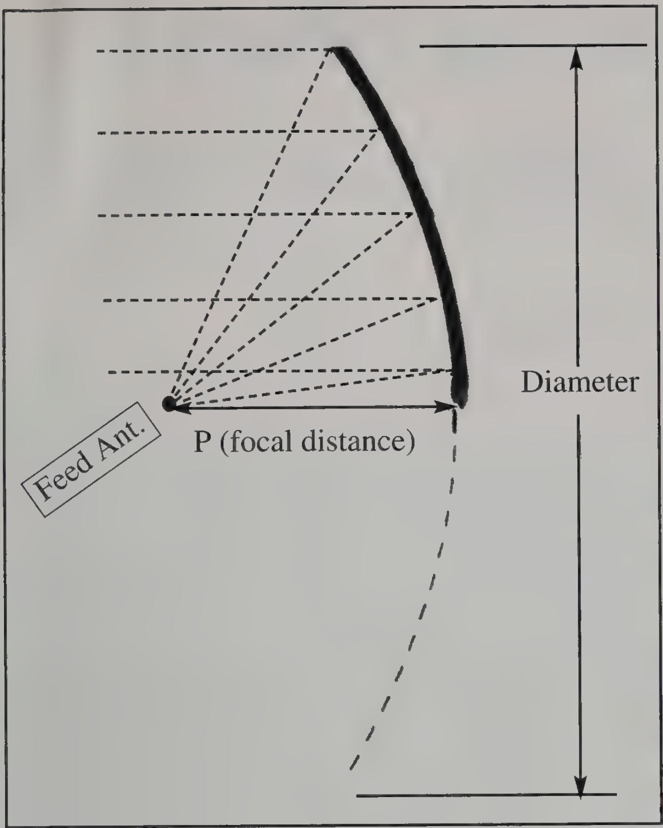

Figure 1. The feed is located to one side of the reflector.

Photo B. The struts are attached to a square plywood center with two bolts.

Photo C. An outside rim is formed from 3.5-foot length of 1/2" × 1/2" modeling strips.

of the full dish. Hence, the feed antenna must have higher gain to produce a smaller beam.) Likewise, a deeper dish (smaller equivalent f/D ratio) should be used for the offset reflector to keep the feed antenna to a reasonable size. The offset dish, besides having greater efficiency than a conventional dish antenna, has an added advantage for EME. It can be mounted with its center of gravity very close to the ground and still fully track the moon. This allows a relatively small mount to be used and makes a polar mount an attractive choice with an offset dish.

Dish Construction

It was decided as a compromise between portability and gain to construct a reflector with a radius of 7.5 feet. This would correspond to a conventional dish of 15 feet in diameter. In the case of our offset dish, only a quarter of a conventional dish's surface is used. This surface was produced from five 7.5-foot lengths of 1/2" × 3/4" wood molding stock, readily available at the local home improvement store. These *struts* were attached to a 1-inch radius wedge-shaped (quarter of a circle) piece of 1/2-inch plywood with two bolts. A 3-foot overlap was used. It would have been preferable to make channels into which the wood struts could be inserted for attachment. I used this method of attachment for the 70-cm, 20-foot portable stress dish I produced more than 20 years ago.[5] This arrangement is stronger and makes assembly and disassembly quicker, but with only five struts the added time was not considered significant.

A rim around the outside of the reflector was made with a 3.5-foot length of 1/2" × 1/2" wood modeling stock with two small (8-32) bolts as shown in photo C. The 3.5-foot length was chosen to produce a reflector with an equivalent (full reflector) f/D ratio of about 0.3. This corresponds to a feed beamwidth of about 90°. (This beamwidth matches a dual dipole feed reasonably well.) Making the reflector deeper using the relation $X^2 = 4PY$, where X is radius of the reflector, Y is the height, and P is the focal distance, will allow a wider beam feed to be used. The dish's focal distance is about 4.5 feet.

The dish's focal length is about 4.5 feet long. A 3.5-foot length of 2" × 3" lumber was used for the main feed support. This piece was attached to the plywood center section using a small wood block. Nylon ropes were run from the feed support to eye bolts at the ends of each strut. The length of these lines was adjusted so that the radius (X distance) of each strut was 7.5 inches. It was discovered that the pull of struts was bending the feed support (and plywood center section). To

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Transmitter Testing—Part 1

Reprinted from *DUBUS** magazine, this is the first of a two-part article on how to correctly measure transmitter quality.

By Leif Åsbrink,† SM5BSZ

The importance of a good dynamic range in receivers is well known among amateurs (see "Receiver Dynamic Range," parts 1 and 2, by SM5BSZ, in the Fall 2004 and Winter 2005 issues of *CQ VHF,* respectively). Receiver dynamic range seems to be one of the important factors behind commercial success or failure of a transceiver model. The quality of the transmitter is, of course, equally important, but transmitter testing does not get the same attention in amateur publications, and methods for transmitter testing are far less satisfactory than currently used methods for receiver testing. There is an obvious reason. The deficiencies in transmitter design that cause unnecessary interference do not create problems to the owner! It is other people—his neighbors on the bands—who suffer from the QRM. It is certainly meaningful to try to improve the standards of amateur transmitters, because today the transmitters are usually the limiting factors, particularly on VHF.

In the previous article of this series[1] the quantity DR_2 was introduced for the two-signal dynamic range of a receiver. The way it is defined, in 1-Hz bandwidth and with 3-dB degradation of the S/N of the weak signal, it makes DR_2 equivalent to transmitter sideband noise. To understand this concept, imagine a receiver that has DR_2 = 133 dB_{Hz} which is what is required on 7 MHz according to Peter Chadwick, G3RZP, stated in an article in *QEX* magazine.[2] Also imagine a transmitter with a sideband noise level of –133 dBc/Hz. Using that receiver, a strong signal from a perfect transmitter will cause a certain amount of S/N degradation of a weak signal. Assuming the same signal levels for the strong and weak signals, the sideband noise from the noisy transmitter will cause exactly the same S/N degradation to a weak signal in a perfect receiver.

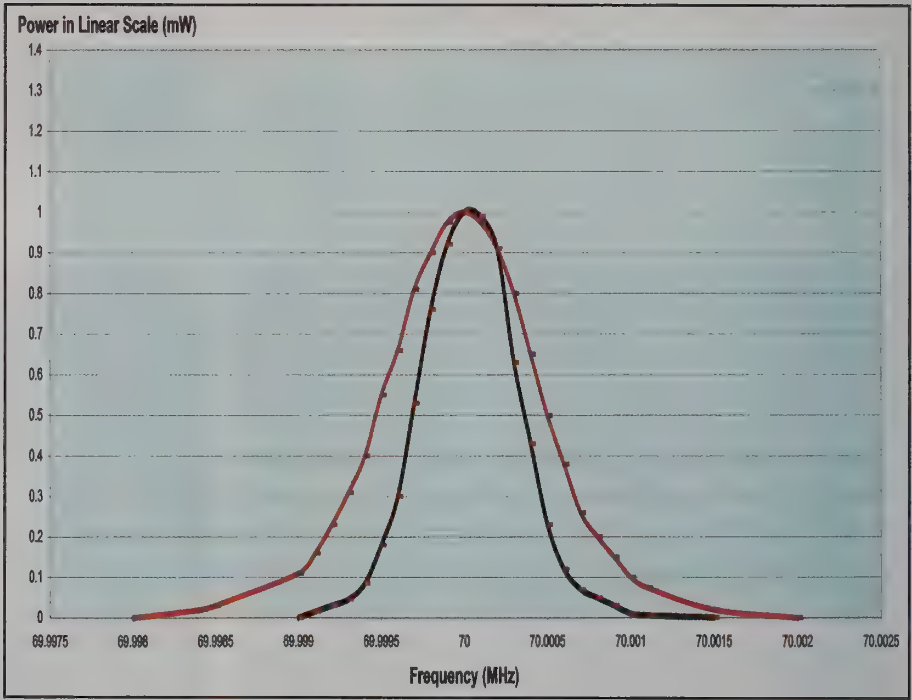

Figure 1. The 1-kHz filters of Tektronix 2753P and HP8591A spectrum analyzers. Numerical integration of these curves gave bandwidths of 722 Hz for the 2753P and 1145 Hz for the 8591A.

A DR_2 dynamic range of 133 dB_{Hz} may be adequate on HF bands, but the situation on VHF is very different. For this dynamic range to be adequate when two 100-watt stations on 144 MHz are beaming towards each other, the stations would need to be separated by as much as 100 km! Thus, it is not uncommon for the VHF amateur to find DR_2 and/or transmitter sideband noise is the limiting factor when trying to work DX. For a typical VHF rig, DR_2 is actually worse than in this example, only between 110 and 120 dB_{Hz} at a frequency separation of 20 kHz. Transmitters are often worse than receivers, even when transmitting an unmodulated carrier.

There is also some confusion about the meaning of the word *test* when it comes to transmitter testing. In a factory one should have a pass/fail test, something that is well defined and produces the same result on the production line as it does in the laboratory. The purpose is simply to find faulty units to make sure they do not reach the market. However, when a transmitter is being tested for a product review, the meaning of *test* is something entirely different. Then one wants a test that reveals all out-of-channel emissions that the test object may produce in real life when operated within the recommendations of the operating manual. Tests done by development engi-

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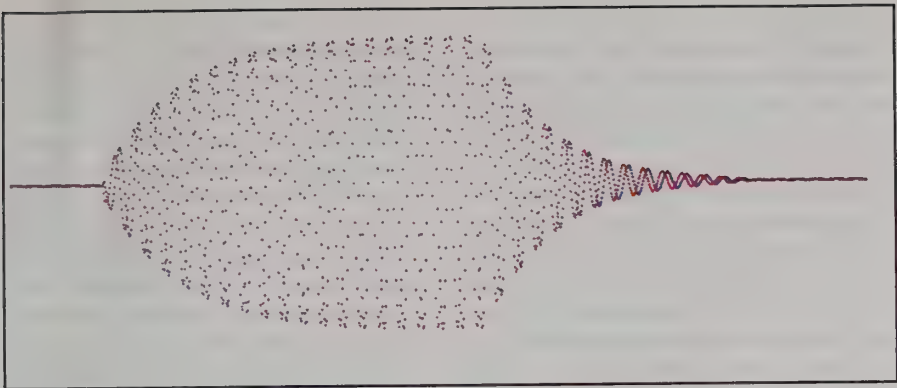

Figure 2. The time-domain waveform of a keyed signal. The keying rate is 110 dots per second, corresponding to about 250 wpm. The waveform is in complex format with I and Q 90 degrees out of phase.

neers are yet another thing. In the development phase one uses a large range of very specific tests on individual building blocks to optimize them separately. Interference can be generated by many different mechanisms, and it is the responsibility of both the development engineer and the review engineer to seek these problems out, using whatever tests are needed to reveal them. While the pass/fail test has only two outcomes, yes or no, the output of product-review testing is a lot of data that should inform the prospective buyer whether the unit in question is suitable for his intended use.

As I see it, the only honest procedure to test the purity of a transmitter's signal for a product review can be described in words such as this: "Connect the transmitter to a spectrum analyzer, and operate it as described in the operator's manual while watching the spectrum. Vary the modulation with pauses and different voice levels for SSB. Observe what happens when the VOX, QSK, or PTT button switches between RX and TX. Note spurious emissions that happen infrequently, and adapt your input to the transmitter to try to make them happen often and repeatedly. In general, operate the transmitter to create the worst-case interference within the limits given by the operator's manual." The output of such a test is the worst-case spectrum and a description of the worst-case modulation input.

One of the main problems in modern transmitters is the ALC, a servo system that is designed to keep the output power below a certain threshold. Any servo system can have stability problems, and the ALC system of a transmitter is no exception. The interference generated can be horrible, but a standardized two-tone test will not show anything at all. It is becoming well known that the simple two-tone test does not reveal much of the real performance of an SSB transmitter. With two constant tones that are separated by 1 kHz, exactly the same maximum power is reached 1000 times each second. With the fast-attack, slow-release ALC characteristic of a typical SSB transceiver, the ALC control voltage will be very close to a DC voltage with just a small saw-tooth-like component superimposed on it. Likewise, the power supplies will be operating under nearly constant load, and their dynamic regulation is not being tested at all. Consequently, the two-tone test will not show many of the problems that may occur during normal usage with voice modulation. It only shows the fundamental linearity of the final amplifier, not the rig as a whole.

The simple test, just measuring the emitted spectrum while modulating the transmitter as if it were on the air, has a practical problem: Professional spectrum analyzers are not good enough! The sideband noise levels of the oscillators in the spectrum analyzer (a multiple-conversion superhet) need to be substantially lower than those in the transmitter under test, or else you are measuring the test equipment, not the transmitter. The ones I have access to have sideband noise levels of about –100 dBc/Hz at 20 kHz, and the best performance I know of in a commercial instrument is –125 dBc/Hz at a frequency separation of 10 kHz (Rohde & Schwarz FSU series). This problem arises from the need to make professional test equipment broadband from near-DC to perhaps several GHz. However, for testing amateur equipment we do not need broadband coverage, and therefore high-quality measurements are not so difficult, as will be shown below.

There is another problem, however, a more fundamental one which requires some discussion. The interference caused by a transmitter—be it noise sidebands, splatter, or keying clicks—occupies a large bandwidth. The level one will see on a spectrum analyzer depends strongly on the bandwidth, the sweep speed, and the detector used. To produce a good characterization of the interference it will be necessary to make two measurements—one which uses a peak-hold detector in SSB bandwidth and another which uses a detector for the average power in a narrow

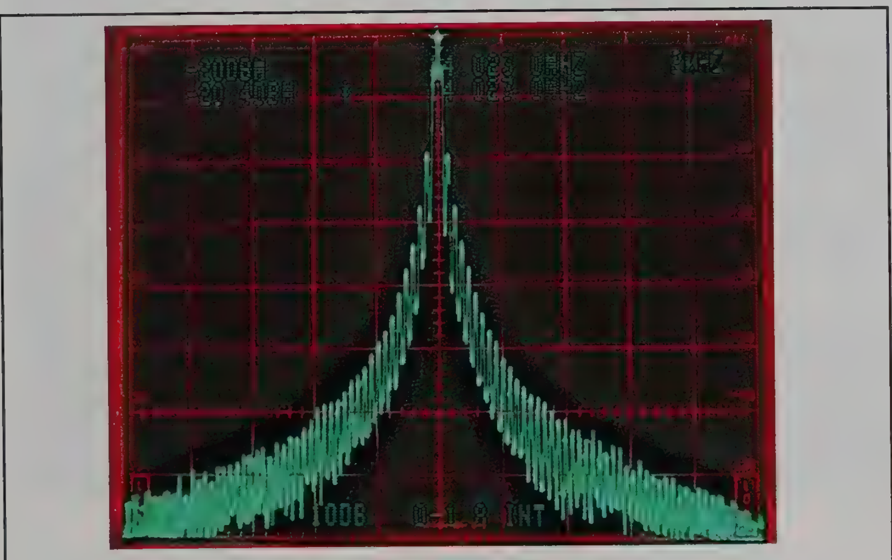

Figure 3. The spectrum of the signal shown in figure 2 as seen on a Tektronix 2753P spectrum analyzer. The scale is 10 dB/div and 2 kHz/div and the filter in use is 100 Hz.

bandwidth. The two measurements are discussed in detail below.

The Average Power Spectrum

The average power spectrum is what we use to show the sideband noise of an unmodulated carrier. When a carrier is modulated, the total power emitted (averaged over the entire transmission) is typically lower by 3 dB in CW and by 10 dB in SSB. At large frequency separations the average power spectrum will show correspondingly lower levels, but at close separations the average power spectrum may actually *increase* due to the tails of the modulation sidebands.

The correct procedure to measure the average power spectrum is to use a true RMS detector. The resulting power density in dB/Hz is then independent of the bandwidth for all bandwidths that are narrow enough to have the same power density. A narrow filter is just averaging the power over time within its bandwidth, and when the detector is measuring true power it does not matter whether the averaging is done in narrow filters in front of the detector or in integrators after the detector. To get a smooth noise floor one normally has to average after the detector, over time, but one might equally well use very narrow filters and average over a range of frequencies. The results would be identical.

However, spectrum analyzers typically have logarithmic detectors. It seems there are standard procedures that specify that the smoothed reading on a spectrum analyzer has to be below some specified limit. The limit is then not truly in dBc/Hz, but there is a bad habit among engineers to put dBc/Hz on such numbers anyway. I have been told that there has been some controversy in the telecom industry about whether the limits one has to comply with refer to dBc/Hz as given by true RMS detectors, or whether the limits refer to the readings one can get directly from a specified spectrum analyzer. It seems to me that this controversy has led to confusion about what the notation dBc/Hz truly means.

To make it perfectly clear, it is a good idea to express the concept in words. The noise-floor power density in dBc/Hz is the ratio of the noise power in 1-Hz bandwidth to the power of the carrier. The power of the carrier is easy. It does not matter what bandwidth or detector one uses; the spectrum analyzer is calibrated to always show the same level for a pure carrier. The noise

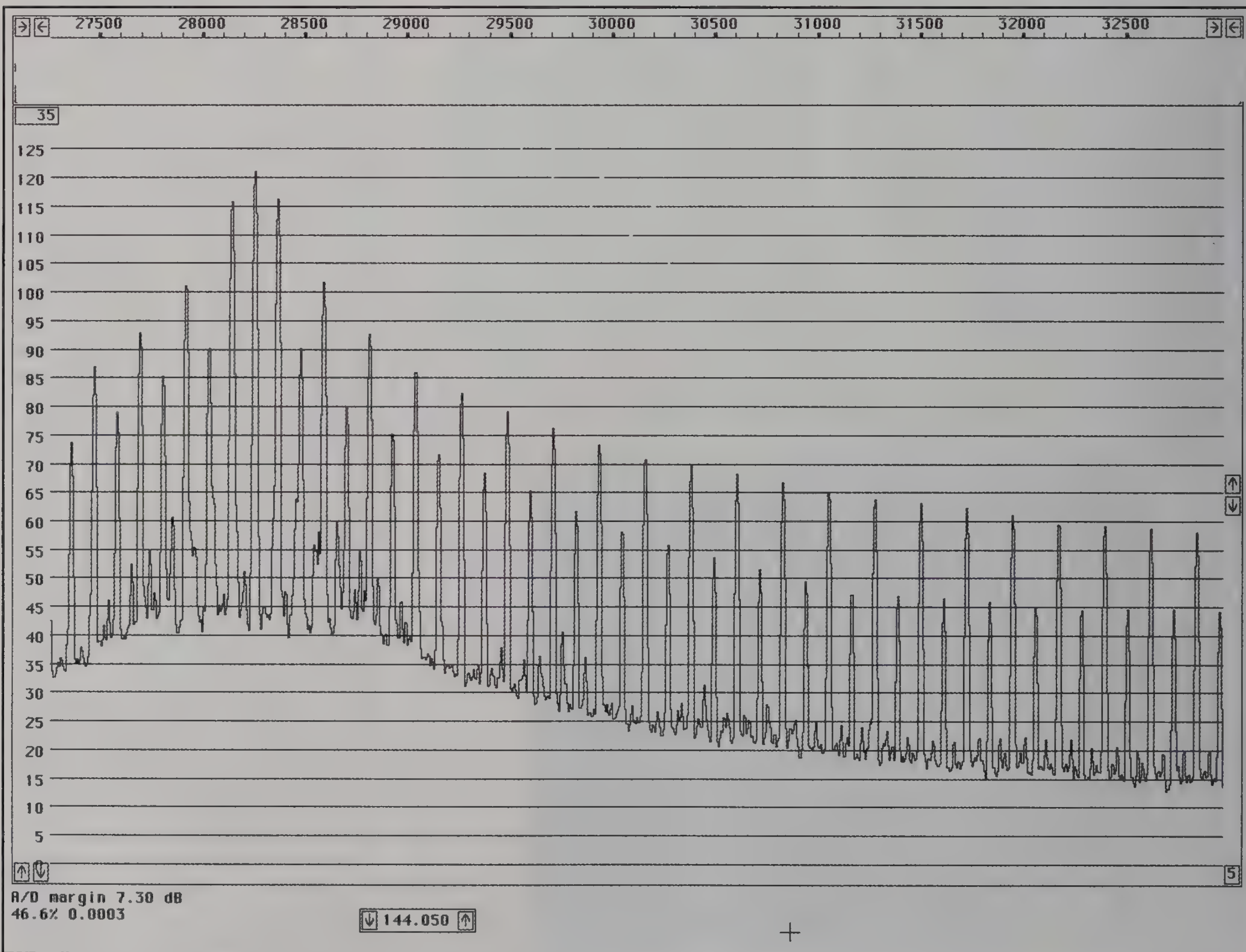

Figure 4. The same signal as in figure 2 as seen on the Linrad screen when zoomed in. The width of this spectrum is about 5 kHz. Here the individual keying sidebands are very visible. Note that the sidebands of even order are weaker. This is because the modulation before RC filtering was a square wave with 50% duty.

power is different. The only way to measure it correctly is to use an RMS detector. A log detector shows a value that is 2.51 dB too low if the signal looks like white noise within the passband. Another thing is that the selected bandwidth of the spectrum analyzer may be different from the true noise bandwidth.

To illustrate the accuracy of sideband noise measurements from standard instruments, I have fed noise and a signal to two different spectrum analyzers, a Tektronix 2753P and an HP8591A. The test signal was a carrier at 70 MHz, –80 dBm from an HP8657A signal generator which was amplified in a deliberately noisy wideband amplifier. The resulting signal had a carrier at –44 dBm with a flat noise floor at –85.0 dBc/Hz as measured by Linrad[3], which uses DSP to provide a true RMS detector after a nearly perfect rectangular filter. Both spectrum analyzers gave noise-floor power densities that did not depend on the bandwidth setting, within a few tenths of a dB. The value obtained from the 2753P was –88.8 dB/Hz, while the result from the 8591A was –86.6 dB/Hz. These were the uncorrected values obtained directly from the carrier and noise-floor levels and the nominal instrument bandwidths. For the 8591A, the bandwidth refers to the –3dB points of a filter that is close to Gaussian, while the nominal bandwidth of the 2753P refers to the –6-dB points of a filter that is relatively flat and has steep skirts. A spectrum analyzer is an excellent instrument to measure its own frequency response, simply by sweeping across a carrier.

Figure 1 shows the responses of the nominally 1-kHz filters in linear power scale. By numerical integration it is possible to find out what bandwidth a perfectly rectangular filter should have to give the same area under the curve as the one observed. (With 10 data points for each kHz, it amounts to taking the sum of all the data points and dividing by 10 to get the noise bandwidth in kHz.) For the 2753P the noise bandwidth turned out to be 722 Hz, while it was 1.14 kHz for the 8591A. The logarithm of these numbers give corrections in dB which add to the 2.51-dB correction for using a logarithmic detector. The theoretical correction for the 2753P was thus +3.94 dB, while it was +1.94 dB for the 8591A. Applying these theoretical corrections, one determines the noise floor of the

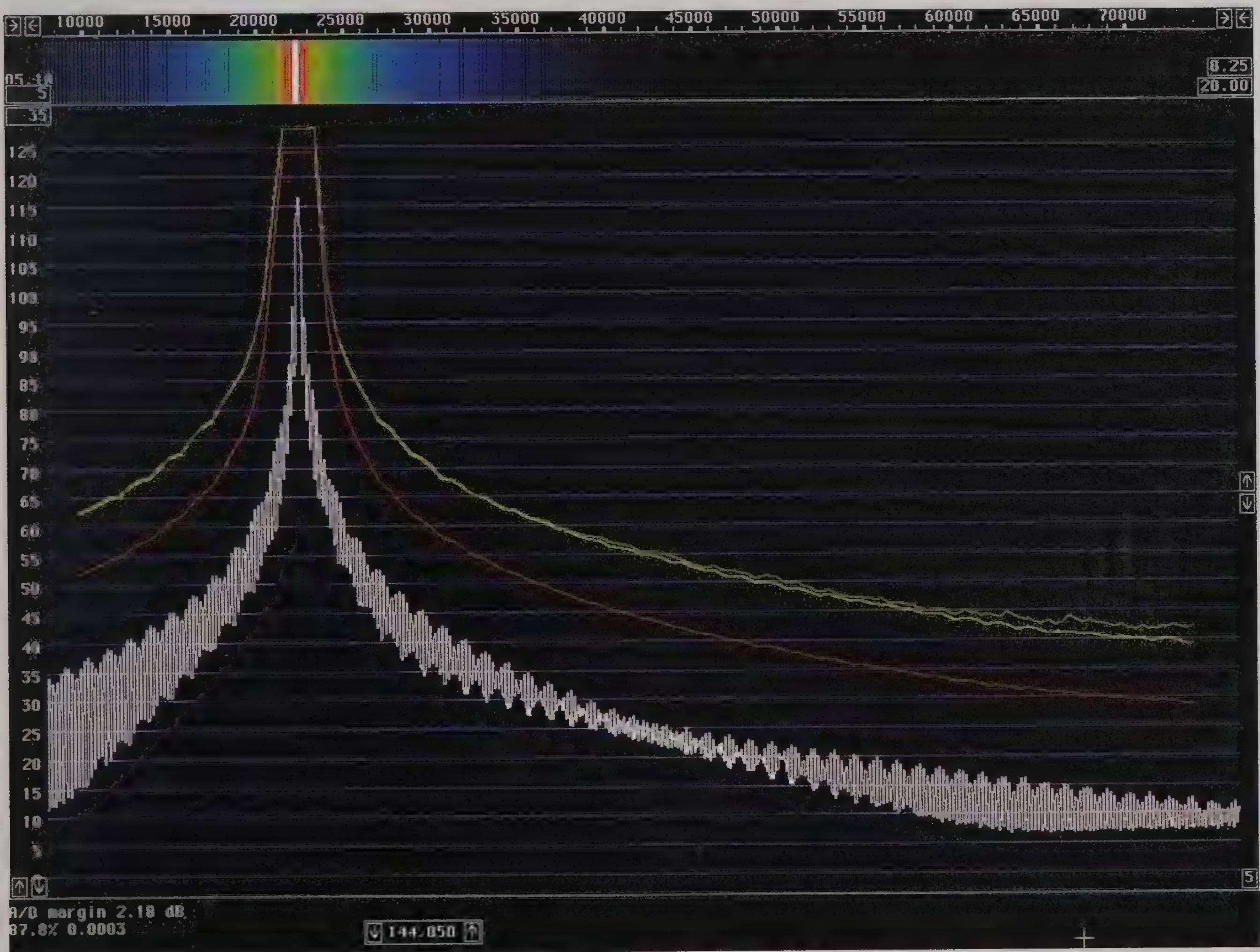

Figure 5. The signal of figure 2 as seen with Linrad in TX test mode. This image shows the spectrum up to 50 kHz above the carrier. The bottom trace is the average power spectrum in an FFT bandwidth of 12 Hz, the same as in figure 4. The screen has only 1024 pixels, so each pixel is the average of 24 FFT bins. This is the reason why the amplitude of the carrier is low. The upper curve is the peak-hold spectrum in 2.4-kHz bandwidth. Very close to it is the average peak-power spectrum. The curve in the middle is the average power spectrum in 2.4-kHz bandwidth.

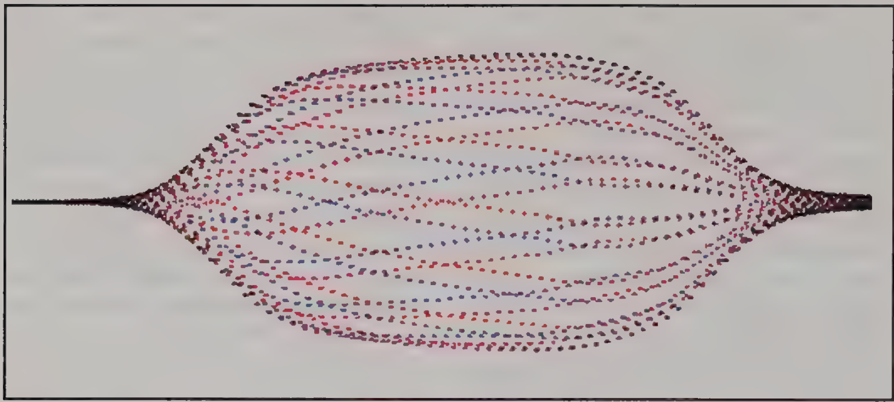

Figure 6. The keying waveform of IC706MKIIG at 144 MHz. The keying is 55-Hz square wave.

above experiment to be –84.9 dBc/Hz from the 2753P and –84.7 dBc/Hz from the 8591A; both corrected values were now in fair agreement with the value –85.0 dBc/Hz obtained from Linrad.

Measurements of amateur transmitters with sideband noise levels in the range –110 to –140 dBc/Hz at a frequency separation of 20 kHz can be done in many ways. Most popular is to use a good crystal oscillator and a high-level mixer to shift the carrier frequency to near zero. The carrier can then easily be removed with a high-pass filter. [4] The noise spectrum is then measured at audio frequency. One will get the noise from both sidebands, so one has to correct by 3 dB for that, as well as for the bandwidth and the detector if something other than an RMS detector is used. This method is used by the ARRL lab in the composite-noise test for *QST* product reviews, but some of the corrections are neglected[4] and the results published in *QST* are more optimistic than the results I find, by about 5 dB.

Another way is to use a good receiver and an attenuator. The receiver should be run in CW or SSB mode without AGC, and the output level should be measured with an RMS voltmeter. This way one gets the signal and noise levels directly, and one just has to know the frequency response of the receiver to calculate the noise bandwidth.

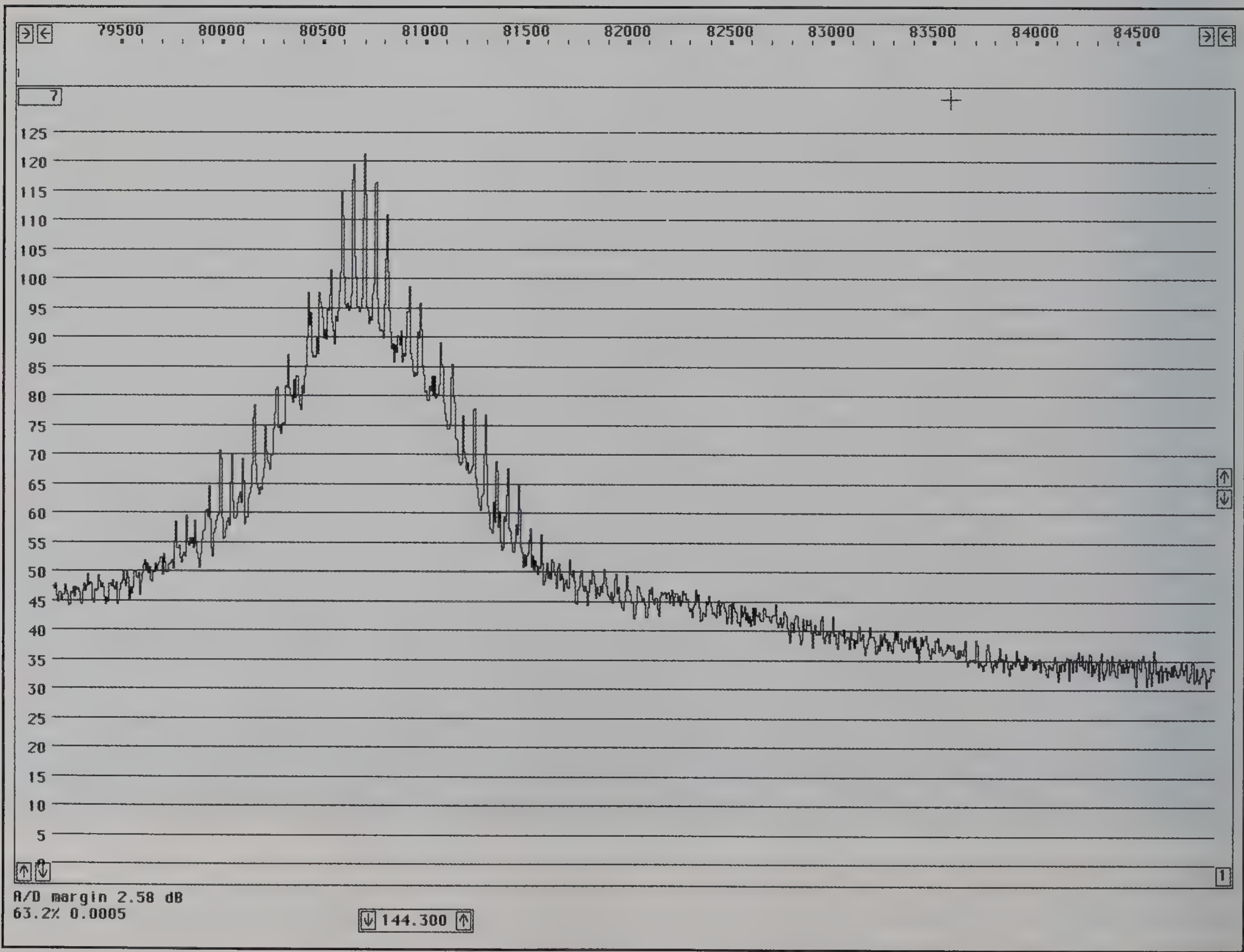

Figure 7. The spectrum of the signal shown in figure 6, an IC706MKIIG keyed at 55 Hz on 144 MHz.

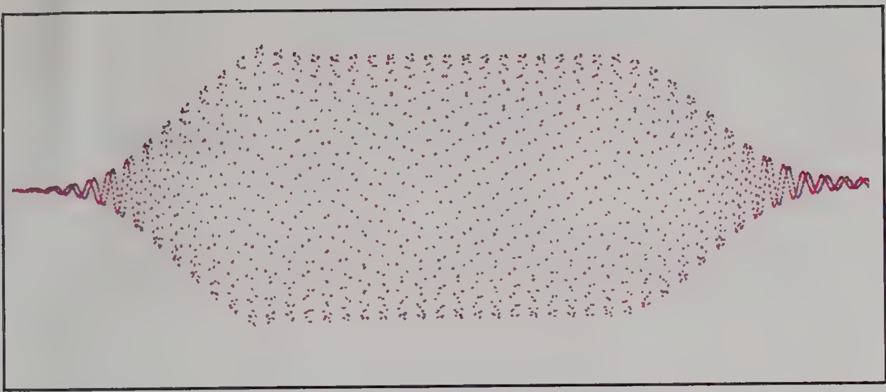

Figure 8. Keyed waveform of the IC706MKIIG at 14 MHz. The reason for this waveform is probably the ALC. It is bad practice (but very common) to use a fast ALC to set the drive power at the desired level. The fast feedback required to bring the gain down rapidly causes wideband modulation that takes the form of keying clicks in CW and splatter in SSB.

By using Linrad with appropriate hardware one can measure spectra directly. The Linrad S-meter uses a true RMS detector. With the WSE converters[5] the noise floor is at –145 dBc/Hz, which is good enough to measure any commercial transceiver on the market today.

It is also possible to use a standard spectrum analyzer such as the 2753P or the 8591A together with a notch filter. When the transmitted signal is centered on the notch, the dynamic-range requirement on the spectrum analyzer becomes much smaller. By reducing the level of the main signal (the carrier for CW, or the wanted sideband for SSB) by about 50 dB, one improves the dynamic range of the spectrum analyzer by a similar amount. This way of doing measurements has the advantage that one can monitor wide frequency ranges and locate spurs and instabilities that occasionally produce signals far from the desired frequency.

The averaged power spectrum is in itself a standardized measurement when given in dBc/Hz. The bandwidth has to be narrow enough to resolve narrowband spurs, but there is no need to specify what bandwidth to use for this particular measurement.

Peak Power Measurements

For white noise, the peak-to-average power ratio depends on the time of observation. For reasonable observation times, the peak power is about 10 dB above the average power regardless of the bandwidth. A carrier or a narrowband spur has the same peak power as average power, but sidebands caused by modulation typically behave differently. In particular, keying clicks are wideband transients that behave like car ignition noise; they have a peak power that increases with the square of the bandwidth. (This is easy to understand, because filters smear a single short pulse out over time by an amount that is inversly proportional to the bandwidth. If the bandwidth is widened from 240 Hz to 2.4 kHz, the keying click will be 10 times shorter. This factor alone would make the pulse power 10 times higher if the total energy content of the pulse was unchanged. However, with 10 times more bandwidth, there is also 10 times more energy in the pulse, so the power will increase with bandwidth by a factor of 100 in total.)

Not only keying clicks behave like this, but also pulses such as those which may occur when the PTT button is pressed. SSB splatter is typically generated when the ALC voltage makes a jump because the drive level is going too high. The abrupt gain reduction causes a wideband modulation that is very similar to a keying click.

Peak power measurements need a standardized bandwidth. I find it natural to use SSB bandwidth, 2.4 kHz or what comes nearest in the available equipment. Well-designed transmitters do not have tails in the modulation sidebands, because they filter the baseband signal well enough, and also they do not have non-linearities that widen the modulation bandwidth by large factors. Just by using a relatively large bandwidth and by looking at the peak power using the maximum hold function of a spectrum analyzer, one can see if a transmitter produces wideband transients even if it happens infrequently. The exact level of the transients is not so important. The really important thing is

(Continued on page 75)

QRP Portable in the ARRL January VHF Sweepstakes

The weather conditions during the January VHF Sweepstakes are nearly always problematic for many operators. Here WB2AMU writes about how he managed the weather challenge.

By Ken Neubeck,* WB2AMU

Almost like the certainty of death and taxes, for many stations in the northeast one consistent fact regarding the ARRL January VHF Sweepstakes is that it always seems to fall on a weekend when it snows! In fact, that almost seems more reliable than the *Farmer's Almanac.*

In the Summer 2004 issue of *CQ VHF,* Bob, KØNR, in his excellent article "QRP Operation in VHF Contests," covered some of the statistics of participation in this category for the VHF contest. He also described some of the tactical setups of those who do QRP operations.

The reasons many give for operating QRP include the challenge, available radios, the thrill of operating outdoors, and the chance to be more competitive. All of these reasons are why I have chosen this category for all three yearly ARRL VHF contests over the past ten years. I also would like to add that the emotional side of it is much more than can be described in statistics. Imagine the freedom that most VHF radio operations have by using smaller antennas that can easily be carried in most cars. In addition, I usually try my best to place in the top ten for the U.S./Canada in the single-operator portable category, a feat that is not always possible when both weather conditions and propagation are not equal throughout the country.

I have done most of my QRP portable operations during the VHF contests from different hills on Long Island, New York, with Bald Hill in the center of Suffolk County being my general preference. The highest hills on Long Island are around 250 feet above sea level. There is a Vietnam memorial on Bald Hill, and I usually conduct my operations from the parking lot near some trees. Both the south shore of Long Island, where the bays are, and the north shore of the island, where the Long Island Sound is located, can be seen from this spot. I have secured annual permission from the county to do radio operations at this site, as there have been some security concerns as well as loitering issues at this location in the past. It is truly good when amateur radio operations can be a beacon of proper use of a park facility.

The VHF Sweepstakes

As there typically is bad weather during the January event, my first goal is to survive. My second is to make sure that I don't drain the batteries too quickly, and my final goal is to make some contacts on the VHF bands! Usually I am successful, although in the past I have needed a battery jump a few times from visitors to the park.

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Here is WB2AMU's QRP setup on one of the hills on Long Island at the beginning of the January 2005 VHF Sweepstakes just before the blizzard began. The 2-meter beam is in the umbrella stand in front of the car, and the two-element, 6-meter beam is in the tree to the left. After 45 minutes the action cooled down, and it seemed like a good time to cease operation, given that over 15 inches of snow would fall overnight. (Photos by Ken Neubeck, WB2AMU)

The January contest does see different propagation conditions at times. In the 2000 contest I witnessed a brief aurora opening and I worked K2AXX in FN12 via aurora. In the 2002 contest I had *F2* conditions where I heard the beacon from Iceland, and subsequently worked several stations in the Washington/Oregon area. Believe it or not, too, most of the

A view of the parking lot of the public park where the hill is located. It had been partially plowed when WB2AMU returned to the site on the Sunday afternoon of the contest.

time during the January contest, usually for about an hour, sporadic-*E* does make an appearance. In 2004 I actually had a DX contact on 6 meters when VP9GE from Bermuda came booming in for an hour at the beginning of the contest via a sporadic-*E* opening.

Every year, no matter which weekend in January the ARRL chooses for the Sweepstakes, whether it is the third or the fourth weekend, it is always cold with snow on the menu for much of the northeast U.S. This streak has been continuous, going back to 2000, according to my records. Perhaps the ARRL should consider going into the almanac business with regard to picking weekends with snowstorms!

In 2005 matters were no different, as the dates for the contest (January 22 and 23) were targeted by the weather service to have a major snowstorm in the form of a nor'easter. As I have always done, I kept a close eye on the weather forecast during the preceding week, and I wondered how I was going to do any kind of portable operation during a major snowstorm. In the past I had encountered significant snow but had been able to work around the storm by leaving the site during the worst of it. For the 2005 event it looked much worse than any of the previous years, as the storm was supposed to start early Saturday afternoon and continue into Sunday afternoon, pretty much wiping out much of the VHF contest!

Adventure in Blizzard Land

Just before noon on Saturday the snow started coming down lightly in the New York metropolitan area. After only an hour there was some accumulation of snow coating the roads. It was getting bad, but I still wanted to attempt a QRP portable operation in the contest, as I had a ten-year streak of being in this category for the January event. At 1:30 PM, prior to the 2 PM contest start time, I decided that I would make a short expedition to the hill but in a streamlined fashion, with just 6 and 2 meters.

As part of my effort to streamline, I decided to forgo the three-element MFJ 6-meter Yagi antenna that I generally use. There would have been at least ten minutes of assembly time, and I figured that this would be pretty difficult to do with the snow coming down. Instead, I opted for my simple two-element, homemade, portable Yagi antenna; I hung that from a nearby tree branch. The three-element, 2-meter MFJ Yagi likewise was quick to set up, with 10 feet of mast sections that I planted into a weighted umbrella stand. Setup took about five minutes, with about two minutes to spare before the contest.

It was refreshing to hear a lot of signals when the contest began, particularly on 2 meters. I was surprised to see that there were actually a few rovers who were adventurous (or crazy) enough such that they were driving through the different grids in the area. I worked N1QVE/R in FN31 during the first hour of the contest. While at my location it was bad with the snow, at least I was settled in one spot. Imagine being a rover who has to drive to multiple locations and deal with the very poor road conditions and visibility of a major blizzard!

Six meters was not very crowded when the contest started, yet conditions on 2 meters seemed very good with loud signals. There actually seemed to be a bit of tropo enhancement working, which is not really that unusual for January, as there are various fronts hanging around that are available for creating ducts.

After 45 minutes, there were not too

The WB2AMU mobile. While covered in snow, it was poised for QRP portable action with the three-element, 2-meter Yagi in the front of the car and the two-element, 6-meter Yagi hanging from the branch on the left. 440 MHz was accomplished with a 12-element Yagi that was switched with the 2-meter Yagi on the mast, and 220 MHz FM was accomplished using a 5-watt HT with a rubber-duck antenna.

Here the three-element, 2-meter Yagi is facing west from Bald Hill on Long Island (grid FN30) just moments prior to WB2AMU working W2FU (grid FN13) on CW in western New York via an apparent tropo-ducting enhancement on 2 meters.

many more stations to work on 6 and 2 meters, and I decided not to tempt the storm conditions any further, as snow was reaching the 3-inch accumulation mark. Teardown was quick, and it took an additional 10 minutes to get home. Then for the next 24 hours the snow came down in furious fashion, topping 2 inches per hour at times, until a final accumulation of 15 inches was reached in my area of Long Island. Higher accumulations were reached farther east of me and in some of the New England states.

Hearing the weather forecast overnight made me initially give up any thoughts of returning to the hill on Sunday, as it was predicted that the snow would continue to fall into Sunday afternoon. It seemed that my adventure of 45 minutes on the air on Saturday was probably going to be the extent of my effort in the 2005 contest.

As it turned out, the snow finally stopped coming down during mid-morning on Sunday. I spent the next three hours digging out of my driveway and helping some friends dig out as well. I thought that maybe in the latter part of the afternoon I would have the opportunity to take a second crack at the hill to take pictures and operate on the VHF bands. At 1:30 PM the roads, while still very poor, were at least passable for me to make a slow trip back to my portable location. This time I brought my antenna for 432 MHz with me as well.

I was very happy at a second chance at the hill after the snow stopped and the roads were somewhat passable. Exactly 24 hours after I left the hill the first time, I arrived there again and quickly searched for a suitable spot to plant and hang my antennas amidst all of the snow that had been piled up by the plows that passed through. Of course, I had my choice of anywhere in the parking lot, as there was no one there except for a few photographers and sledders passing through.

There were some definite 2-meter enhancements working, most likely the result of different weather fronts in the area. I managed to contact N1JEZ in FN44 on the band on SSB, and a short while later, W2FU in FN13 on CW. It was kind of an eerie feeling hearing these far-away signals on 2 meters while operating in the snow. As I only had 220 MHz on my HT, I worked two stations in FN31 (K1TEO and WB2SIH) running just 5 watts with a rubber-duck antenna. Based on my past experience, I suspect that I might have been the only station on Long Island using 220 MHz during the contest.

I might add that the temperature on both days was well below the freezing mark, with Sunday being a crisp 16°F. Luckily it was not windy, and I was bundled up with extra layers of clothing, a very important thing to remember when operating portable outside in the winter. Ice on the parking lot was also a concern, and I did slip once. One of these years I hope we get a January VHF contest in the northeast without snow, ice, or wind!

The Results

In all I made 32 QSOs with 11 multipliers over four bands for two separate one-hour sessions on the hill. I was just happy to have made any contacts at all, given the adverse weather conditions! Two meters was clearly the best band here, as I made 20 QSOs on that band.

Overall, the level of participation was down from previous January event. No doubt the snow created some havoc for some stations with regard to travel, and in some cases there may have been power loss. Rover activity was probably limited to the very beginning of the contest and the very end, when there were fewer issues involving travel.

Some Final Thoughts and Analysis

The main advantage of operating at a somewhat remote location is the lack of overhead power lines and subsequently less power-line noise. This year, because of the snow affecting the power lines, power-line noise seemed to be a major problem for many stations operating on 6 and 2 meters during the contest. A number of stations in nearby grids could not copy me because they had high levels of power-line noise on their receivers. I found out later from the various chat pages that several stations had power-line noise in all directions and were severely limited in making contacts during the contest.

Another thing that I have found very interesting is the fact that quite often 2 meters may have some enhanced conditions that very often go unnoticed unless there is a VHF contest or

an event such as Field Day going on. The exception is when there is a strong sporadic-*E* opening such as the one which occurred on July 7, 2004 or some of the aurora openings of the past year. Word spread rapidly about these openings on the internet spotting sites. Quite often, however, and almost on a regular basis, there are some decent tropo enhancements on 2 meters (as well as on 220 and 432) that occur and are not taken advantage of in many locations in the U.S. and Canada. VHFers perhaps do not frequent the band as much as they should, particularly the lower part of the band, where most of the weak-signal activity occurs. It would be great if on a daily basis more VHFers gave a short call on 144.200 MHz and checked for beacon activity for such tropo enhancements.

Also, it is a well-known fact that some of the categories in the ARRL VHF contest have been seeing a decline in participation over the past ten years. I can remember some the significant efforts back in the 1990s, when Zak, W1VT, and others ran QRP portable and tens of thousands of points were accumulated. There are many reasons for the decline in activity: aging of the ham population in general, rules format, and the limited interest in VHF contesting in general. I also think that a major reason is the amount of effort it takes to transport equipment to a portable location as well as find a suitable location that is available to the public.

The survey in Bob, KØNR's article mentioned previously shows that most QRPers usually only operate three or four bands in VHF contests. When you are going to a portable location, it does become quite an effort to bring equipment for more than four bands, particularly when you need transverters. It is much easier when you only have to bring one or two radios for a QRP effort. Maybe the ARRL should determine whether the current VHF contest should truly be called a VHF contest (6 and 2 meters, and 220, with possibly 432 MHz) instead of adding UHF and the microwave bands! (Remember, there are several dedicated microwave contests sponsored by the ARRL throughout the year.) I also have noted in the results of many of the VHF contests that in the New York City/Long Island section there are no listings of any stations using bands higher than 432 MHz. It appears that it is somewhat of a chore to find that right location for setting up a operation on those UHF and microwave bands in a metropolitan/suburban area.

Also, the ARRL Contest Advisory Committee should seriously consider increasing the value of each 220-MHz contact (such as making these contacts worth 3 points instead of 2). As I look over the scores from the past VHF contests, it seems that the most common band mix used by stations is 6 meters, 2 meters, and 432 MHz (designated as "ABD" for the band listing in the contest results). Again, in the New York City/Long Island section there are at most two stations operating on 220 MHz for any of the three ARRL VHF contests. I imagine that this might be a situation that exists in other areas of the country as well. While it is very difficult to get a 220-MHz SSB or CW transceiver, FM is a fairly viable mode and operators should pursue this more during a contest event.

Every January's VHF Sweepstakes is an adventure, and the 2005 event was particularly so with the occurrence of a major blizzard here in the northeast. You have to be a bit fanatical—or even nuts (!)—to participate in a contest in that kind of situation in a rover or portable category, but I can tell you it is an experience very different from just operating in the comforts of a home QTH! ■

By Rich Arland,* K7SZ

VHF+ BEGINNER'S GUIDE

All you need to know but were afraid to ask . . .

Setting Goals and Gathering Information

Welcome to the "VHF+ Beginner's Guide," the newest addition to *CQ VHF* magazine. My name is Rich Arland, callsign K7SZ, and I will be your host as we explore how to enjoy the VHF and UHF world on a frugal budget. The purpose of this column is to enlighten the newcomer to the VHF bands on how to choose gear, set up a station, build and erect antennas, and find radio-related bargains to keep costs down while wringing the maximum performance from the station.

By way of introduction, let me briefly give you my biography. I am a 59-year-old retired USAF Master Sergeant, with a wife (the beautiful and talented Patricia) of 24 years , four grown children, and five (soon to be six) grandchildren. During my 20-year Air Force career in long-haul and tactical communications, I spent almost 15 years overseas operating amateur radio from locations such as the Azores (CT2BH), Japan (KA2AA, prior to reciprocal licensing), England (G5CSU), and Germany (DA2NE). Currently I teach vocational electronics at the State Correctional Institution-Dallas (Pennsylvania) to incarcerated male inmates. Part of my job with the Department of Corrections is technical service countermeasures (TSCM). In addition, I am a DoC/PA State Police certified hostage negotiator, and will be receiving my FBI certification sometime later this year.

I was first licensed in 1963 as KN7YHA, upgraded to Technician Class the following year, and eventually worked my way up to Extra Class in 1987 (and, yes, I can still copy CW at close to 30 wpm!). I had a chance to grab a vanity call in 1996, and I retired the K7YHA callsign in favor of a 1X2 call: K7SZ.

Some of you might recognize my callsign and/or name as being associated with QRP (under 5 watts amateur radio), and to that I must plead, "Guilty as Charged!" In 1965 I joined the QRP Amateur Radio Club International and have been an advocate of QRP for the last 40 years. I have written for the radio hobby press for over 30 years, starting with *The Milliwatt* magazine in 1974. I wrote the QRP column for *Worldradio* magazine for a few years in the late 1980s and early 1990s and switched to the satellite column for another several years. I have also written technical articles for *Monitoring Times Magazine, CQ, QST, The QRP Quarterly, The Homebrewer,* and *CTM Magazine.* For four years I wrote the "QRP Power" column for *QST,* and I have written five books on low-power communications; the current one, *The ARRL's Low Power Communications, the Art and Science of QRP* is selling quite well, with the proceeds going to finance my ham radio hobby. Currently I write the "Homeland Security" column for our sister publication, *Popular Communications.*

Over the years I have had many stations all over the U.S. and overseas. I have had my share of gear, both new and used. I love to restore older vacuum-tube radio equipment, thereby preserving a piece of radio history for future generations to marvel at and enjoy. My current "Boatanchor" collection consists of an R-600 Zenith Transoceanic receiver; a most-rare Zenith "Global" receiver; Hallicrafters S-38 (six-tube model from 1946), SX-71, SX-62A, S-51, S-120, and SX-117 receivers; a National NC-57 (W3NQN's original receiver from 1947); an HT-44 Hallicrafters transmitter (matches the SX-117); a Drake 2B receiver; a Heathkit HW-202 2-meter FM rig, HW-101 HF Xcvr, SB-301/401 Twins, HR-10B receiver; Johnson Viking Adventurer (these last two were my original Novice station radios); and a few dozen other rigs that have gone through the K7SZ shop to be traded for "needed" gear over the years.

While not officially cataloged as "Boatanchors," since they are solid-state rigs, I recently obtained the entire ensemble of "Bookcase Radios" (circa 1980–85) from ICOM: the IC-202, 215, 402, and 502 transceivers, which cover 2 meters, 70 cm, and 6 meters, respectively. My upcoming purchases will include a Yaesu FT-221R, a first-generation 2-meter multimode transceiver; an Elecraft K2 transceiver (kit with a host of options) and a set of their transverters for 6, 2, and 1$^{3}/_{4}$ meters; and a Ten-Tec Paragon HF transceiver for HF DXing and contesting and to use as an IF with VHF+ transverters.

Money, Money, Money

Ham radio can be a very expensive hobby. So much so, that often marital relationships become strained and budgets get scuttled all for the sake of the radio hobby. This is not a good thing. As noted earlier, my writing money offsets my participation in ham radio. If it weren't for this expendable income, I would be hard-pressed to find a way to afford the various aspects of the amateur radio hobby. Therefore, this column is dedicated to helping anyone interested in the VHF+ bands set goals, obtain gear, and get a station on the air that will fulfill the assigned goals while keeping expenditures under control.

VHF+—What is it?

Traditionally, VHF starts at the upper end of the 10-meter band (30 MHz) and stops at around 300 MHz. Here it changes names and becomes UHF (300 MHz to 3 GHz), then SHF, and finally EHF, as we go up through the 70-cm band (432 MHz) and into the microwave regions of the spectrum. To sum up things and keep the ends nice and tidy, it is easier to refer to all VHF, UHF, SHF, and EHF ham radio operations as VHF+.

Why go up in frequency when the HF bands are available and they provide worldwide communications on a daily basis? Sometimes it is predicated on the class of license. For many, many years, the Technician Class ham license was the stopping point for those folks who did not acclimatize well to the CW requirement of 13 and 20 wpm for the higher classes of amateur radio licenses. Techs had everything above 30 MHz, so why worry about the code just to get onto the low bands? In the early to mid 1970s 2 meters FM became very popular, so localized, interference-free communications became a reality to the holders of Technician Class licenses. Also, during that time Project OSCAR (Orbital Satellite Carrying Amateur Radio) became do-

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able on a budget, so a Tech licensee could have fun DXing via the low Earth orbit (LEO) birds.

For others it was the challenge of developing new gear and new modes in the microwave bands that held an attraction. The VHF+ region offers huge amounts of spectrum for experimentation by technically inclined radio amateurs. It wasn't all that long ago when if you wanted to get on 2 meters you had to build most, if not all, of your station. I can still remember the 2-meter homebrew station that the ARRL touted in one of their reprint articles well into the 1970s. If you were not involved with FM voice transmission modes in the 1970s, it was almost mandatory to build your own transverters to gain access to 6 meters, 2 meters, $1^3/4$ meters, and 70-cm SSB/CW modes for weak-signal work.

All this experimentation had a price: knowledge. That's right; those hardy radio amateurs who started exploring the VHF+ bands became quite knowledgeable about the specialized circuits used in VHF and UHF radios, as well as the specialized construction techniques needed to make these homebrew rigs, antennas, and accessories perform at these frequencies.

Fortunately for us, all this information has been preserved in magazines such as *QST, CQ, Ham Radio, QEX,* and *Communications Quarterly.* Even though some of this information is quite dated, it is still valuable and thankfully, most of it is still available to us via the CD ROM versions of these great publications. What? You don't have all of *QST, Ham Radio, QEX,* and *Communications Quarterly* on CD? Shame on you! Well, let's make that one of your initial goals: start collecting VHF+ data in the form of CDs of these outstanding publications. The more information you have on hand, the easier it is to make decisions about whether it is more cost effective to build or buy a piece of gear, accessory, or antenna.

Setting Goals

So far I have mentioned "goals" several times. Setting goals is an important process that allows us to make a list of objectives to fulfill an ambition. It provides us with a logical, step-by-step process of how to get from point A to point B. Setting goals also provides us with discipline. We become focused on achieving the goal, and the plan seems to "fall together" like it was meant to happen.

Earlier I mentioned an upcoming purchase of a Ten-Tec Paragon HF transceiver. Around my birthday (early March) I found a nice used Paragon on eBay. Several of my good friends have Paragons, and they had been my sounding board regarding the pros and cons of buying and using this first-generation Ten-Tec synthesized HF transceiver. My buddies had convinced me that buying a Paragon made good sense in that they are reasonably priced, great performers, and can be computer controlled (a must at the K7SZ station). The Paragon receiver is extremely quiet, with low phase noise, a must for use on transverters. The beautiful full break-in keying (QSK) that is a trademark of all Ten-Tec transceivers is also part of the total package. Although big (by today's standards), the Paragon is a solid, cost-effective performer.

Taking all of the above into account, I started closely watching the bidding on this excellent rig, hoping to put in a winning bid of around $750 to $800.

Unfortunately, I was unable to submit a winning bid without going above what I had set aside from my writing money for radio purchases. Sure, I could have grabbed some cash from the family budget and repaid it within a few weeks, once a royalty check arrived, but that was *not* the deal I had struck with my wife. Rather than become obsessed with buying a Paragon on eBay, I decided that another Paragon would be listed in the future and by that time I would have amassed the necessary funding from my writing to be assured of winning the auction.

Discipline: Goals instill discipline. While Patricia would undoubtedly not have said a word had I raided the family budget to bid on the Paragon, *I* would have known that I had not abided by one of my principal goals—using my writing money to finance the radio hobby. Once you break discipline it is easy to become complacent and then all the goal setting in the world is for naught. Then you lose focus of your ultimate objective, in this case to own a world-class HF transceiver that would also function as an IF strip for transverters for use on the VHF+ bands.

Setting goals, especially with regard to money, is a great way to ensure that you obtain what you really want and not just buy radios and accessories "willy-nilly" on a whim just because you might need it some day. This not only saves money, it saves space in the shack, and I don't know anyone who has enough room to just stockpile gear for use "some day." At this point I am reminded of a line from a *Star Trek* episode, "Amok Time," where Mr. Spock, after killing Captain Kirk in mortal combat, confronts his concubine's suitor with the words: "Having is sometimes not as fulfilling as wanting" (or something to that effect). Many times I have let lust for a radio overcome my better judgment and have regretted purchasing that particular rig for one reason or another. Yup, I like goals a lot. It keeps me from making costly mistakes.

Doing Homework

Chalk it up to being a teacher by trade, but doing research (homework) is one great way to avoid buying a piece of gear, either new or used, that turns into a bad decision in the long run. There have been thousands upon thousands of words written in the form of product reviews describing the traits of various pieces of gear, accessories, and antennas. All the major ham magazines have product review pages, and in the past the ARRL has published two volumes of reviews from the pages of *QST* of the last 20–25 years. Basically, there is no excuse for not knowing about a rig, station accessory, or antenna before plunking down your money or plastic. This is not to say you can't get a "lemon," but the chances of buying a rig

that does not do what you want is greatly reduced when using product reviews to guide your choice of station components.

Another great method of obtaining information on a piece of gear is to ask how other hams who have purchased the same piece of gear like it. In the case of my Ten-Tec Paragon, Tim Cook, NZ8J, and Vic Klein, WA4THR, both absolutely love this rig and have in-depth knowledge regarding its inner workings. Both of these technically adroit radio amateurs have pulled maintenance and mods on their Paragons and stood ready to answer my questions regarding specifics about this radio. Buying a Paragon, in my instance, was not an ill-informed choice at all. Not only did I read the product reviews in back issues of several ham magazines, I also had two individuals provide me with all sorts of interesting insights into this radio and how it works.

For me, obtaining a Paragon was a cost-effective way of killing two birds with one stone. On one hand I would have an excellent HF rig that was up to the task of doing some serious DXing and contesting, and on the other hand it would function as a low-noise IF strip for the VHF+ bands.

Let's Recap

In this first installment of this column I have introduced myself and we have covered two of the basics for assembling a successful VHF+ station on a budget: namely, setting realistic goals and gathering information (research) on the gear we intend to use to get the job done.

With that in mind, and being a teacher to the bitter end, here is your assignment: If you are new to the VHF+ arena, first think about what you want to accomplish, then think about the dollar limits you are going to be restricted to, and make up a simple set of *realistic* goals for your first VHF+ station.

Hint Number One: Springtime is 6-meter time. Six is "the Magic Band" for sure. In mid-February 2005 there was a 6-meter opening in the late afternoon on a weekend, and using the IC-502 6-meter SSB/CW rig running only 3 watts PEP to a discone scanner antenna that was not even supposed to cover the low end of 6 meters, I worked a dozen stations in southern and middle Florida and South Carolina in about an hour and a half. My signal reports varied from 51 to 59+ during this time! This was with only 3 watts PEP to a non-resonant antenna about 3 feet above the roof of my house!

Total cost of the rig was $130 (used on eBay), and $60 for the discone scanner antenna, which pulls quadruple duty on 6 meters, 2 meters, and 70 cm and feeds my scanners! Fun? You have absolutely *no* idea! The really great part was explaining my station to the other guys I was working (most of whom were running 100–500 watts to rotatable Yagi antennas) and hearing their comments of utter disbelief!

Now I am not out to convert the readers of this column to QRP. Far from it, as several installments of this column will cover building "brick" amplifiers for several bands.

Hint Number Two: Summertime is ARRL Field Day time and VHF/UHF contest time. Anybody want to give some serious thought to putting together a mobile/portable contest station to support a local club's FD efforts or to go "roving" during contests?

Next time I will share my goals for a cost-effective three-band VHF+ contest station using three ICOM IC-X02 series "Bookcase Radios" as exciters and homebrew antennas for 6 and 2 meters. Until then, have fun and do your homework! 73, Rich, K7SZ

By Keith Pugh,* W5IU

Artificially Propagating Signals Through Space

A Complete Ground Station for AO-51

On June 29, 2004, AO-51 was launched. Since that time it has been checked out in most of its modes and mode combinations. These modes and combinations are controlled by the command station to maintain the health of the satellite and to satisfy the desires of the users. The current mode schedule is posted at <http://www.amsat. org> and should be referred to frequently for updates.

Normally, six days per week the satellite operates simultaneously in two modes: Mode VHF/UHF (V/U) Analog and Mode V/U Digital (low data rate). The digital downlink also carries the telemetry stream used to monitor the health and welfare of the satellite.

On Wednesdays UTC the satellite is usually in Experimental Mode and may be in any of several possible modes as set up by the command station. These modes can be combinations of different RF uplinks and downlinks, different digital data rates, different power levels on the uplink and/or downlink, and different control procedures (with or without PL tones). Uplinks have been checked out on 10 meters (HF), 2 meters (V band), 70 cm (U band), and 23 cm (L band). Downlinks have been verified on 70 cm (U band) and 13 cm (S band). Operations at data rates of 9k6 baud and 38k4 baud have been verified. Higher data rates are possible within the satellite architecture for future verification. The 9k6 and 38k4 modulations are FSK. The satellite also supports PSK-31 utilizing the HF uplink.

As you can see, a ground station to cover all of the possible combinations seems formidable. Here we will attempt to break down these combinations, categorizing them by their effects on the various elements of a satellite station. We will also attempt to illustrate how the station can be put together incrementally and gradually built up to full capability. It will also be pointed out that the station can be customized to utilize as much of your current station as possible. This column is not intended to "scare you off." Many hours of enjoyment are possible with AO-51 and a very simple, inexpensive station. It only becomes more difficult when you try to do it all at once.

Station Computer and Software

These days a good station computer is essential for operating on a satellite as sophisticated as AO-51. The operating system can be Windows®, Mac, or Linux, but more software is readily available for Windows®. One could argue that a computer is not needed to actually operate the analog modes, but even these modes require knowledge of when the satellite will be above your horizon and where the satellite is at any given time. A station computer running a suitable satellite tracking program is the best solution, even if it is only used to make the predictions and print them out to take along with you on portable operations. As much as some of us hate to admit it, connectivity to

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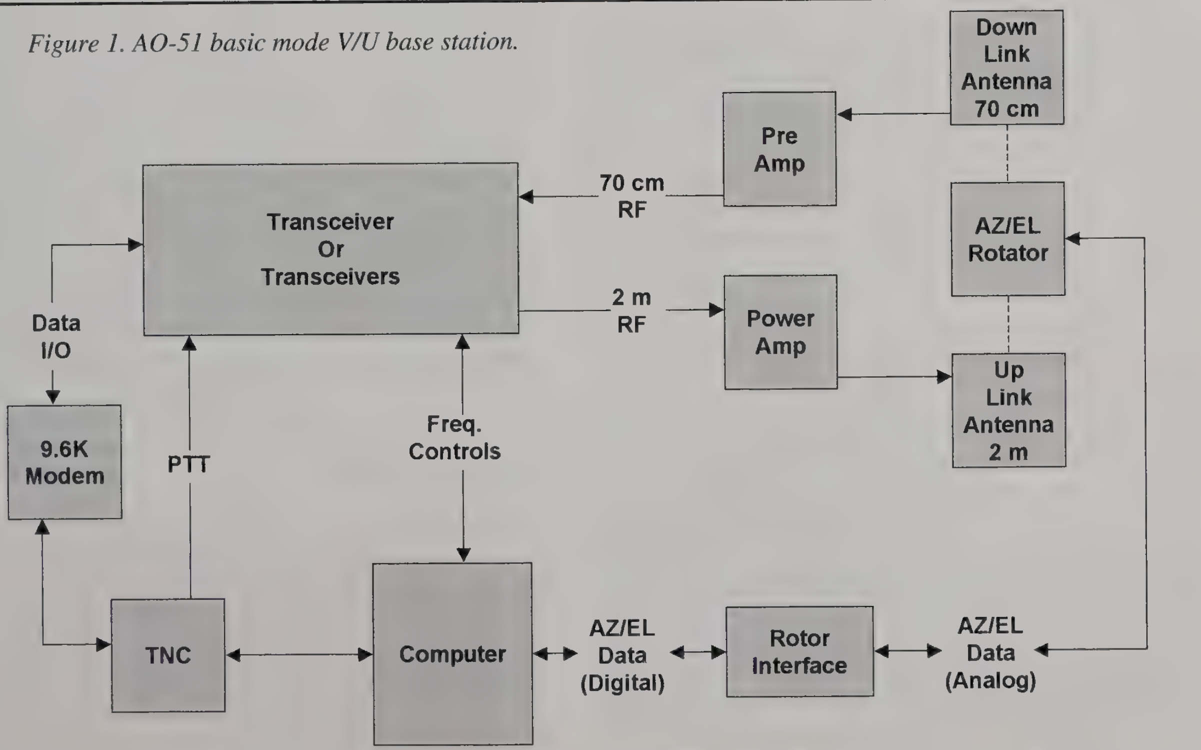
Figure 1. AO-51 basic mode V/U base station.



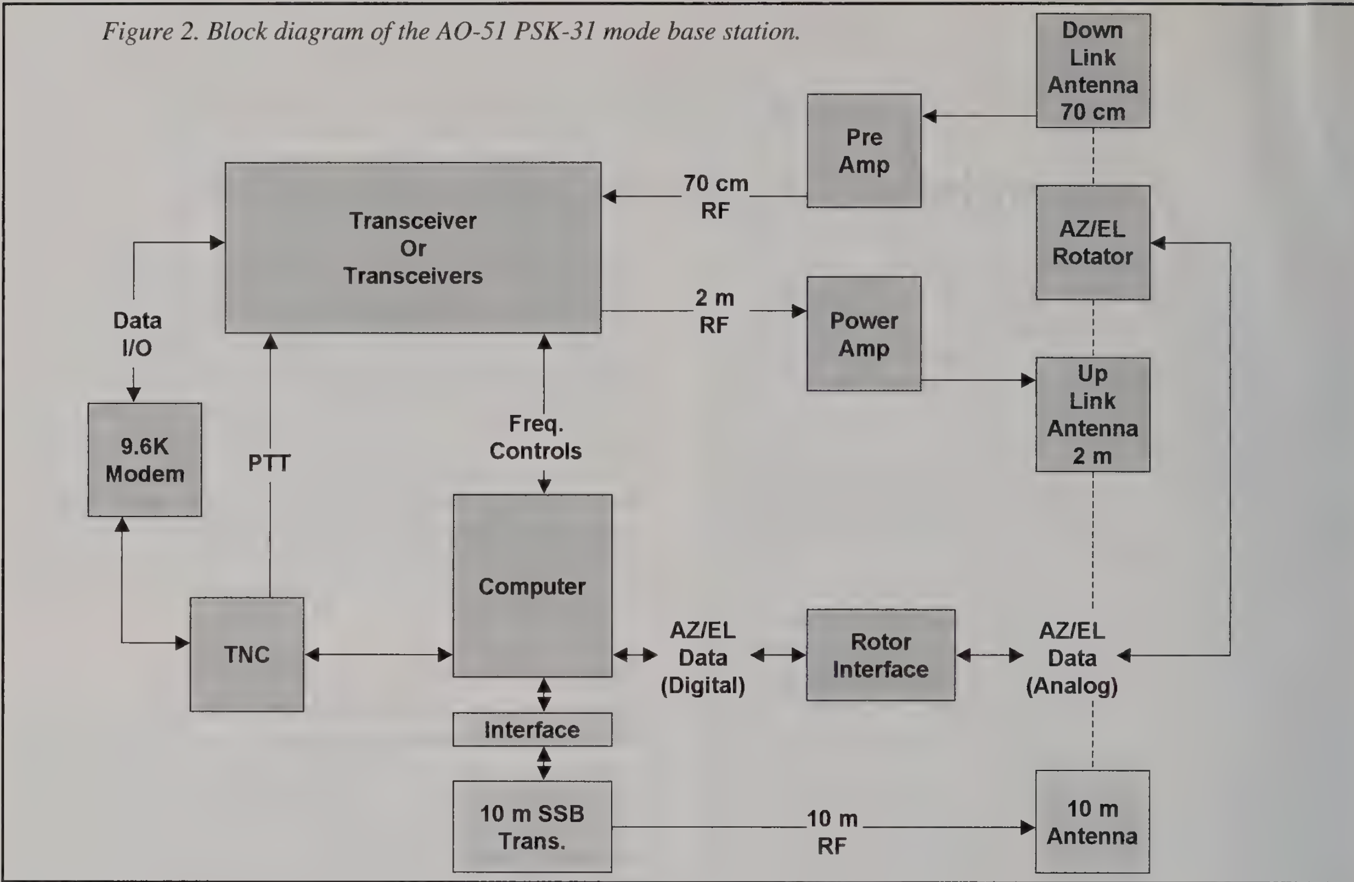


Figure 2. Block diagram of the AO-51 PSK-31 mode base station.

the Internet is essential to keep up with the mode schedule and other news.

For operation with the digital modes, the computer is required to prepare and decode the messages utilizing software such as Wisp (for messages), TLMEcho (for telemetry), or various programs for PSK-31.

For station control the computer is increasingly valuable to control pointing of the antenna and the uplink/downlink frequencies. As the operating frequency increases and as antenna beamwidths decrease, computer-aided station control becomes very important, especially on a Low Earth Orbit (LEO) "bird" such as AO-51. The aid of a computer is very helpful for attended station operation, but it is absolutely essential for automated operation. Today good software is available to do these functions with proper interfaces between the computer and the station equipment.

Station Receiver, Transmitter, or Transceiver

The key here is to realize that it is not necessary to do all of the possible combinations in one piece of hardware. There are some transceivers on the market today that will perform most of the functions necessary in one box, but I have not seen a single transceiver that will support everything possible with AO-51. Even if such a transceiver were available, it might not be economically feasible to own it.

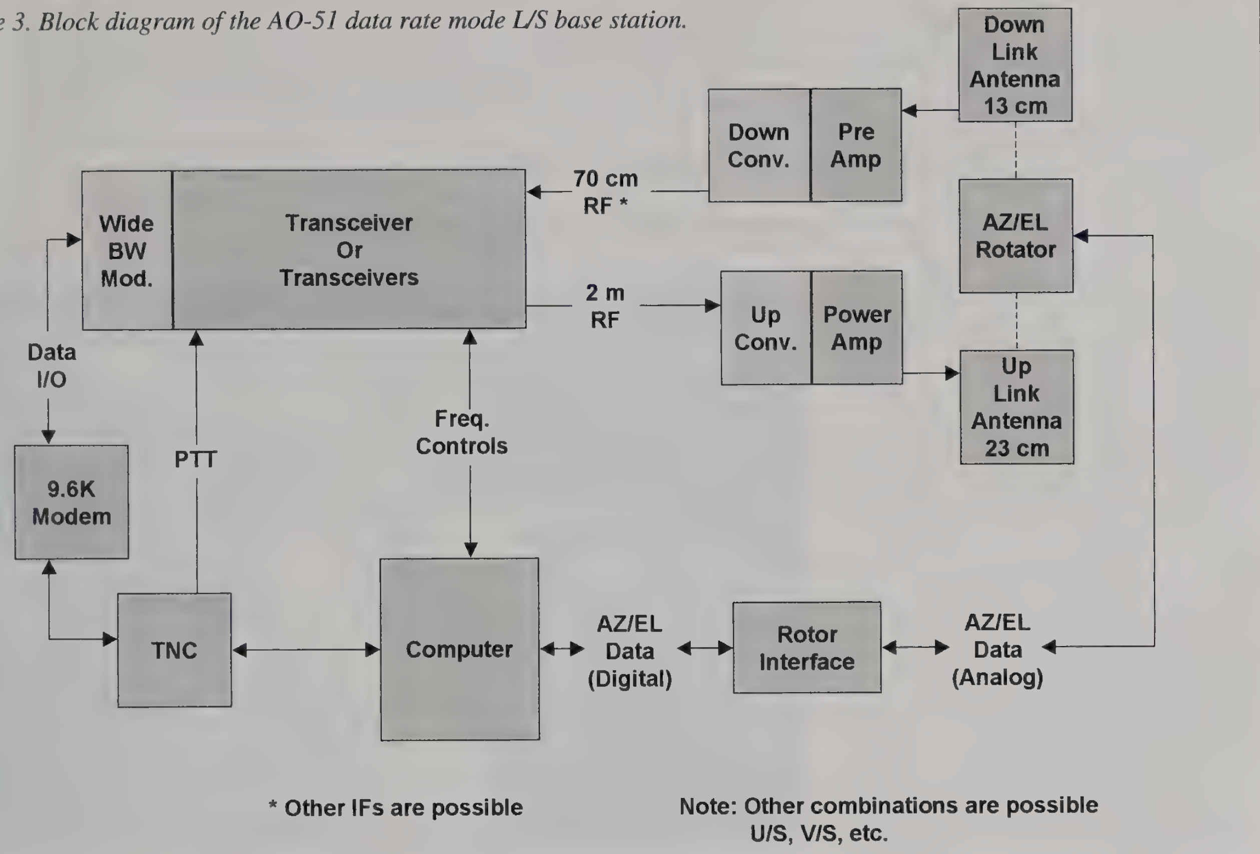
A "do everything" transceiver would have to transmit on bands from HF through L band and receive on bands from V band through S band. It would have to accept computer control of frequency, mode, and bandwidth. The last item, bandwidth, is particularly tough to support for the high digital data-rate modes. The high data-rate modes also place the greatest constraints on system-link budget—i.e., higher antenna gain, better receiver noise figure, more power, and lower losses are required to support the greater bandwidth. Automatic frequency control is another desirable feature in the presence of the high Doppler rates encountered with AO-51 when operating at the L- and S-band frequencies.

To illustrate this, I offer the following comparisons of three popular satellite radios—the Yaesu FT-847, Kenwood TS-2000, and ICOM IC-910H. The FT-847 and the TS-2000 have HF capability, so they support the PSK-31 uplink on 10 meters, while the IC-910H will not. The IC-910H has a good AFC (automatic frequency control) function that is very useful for receiving in the presence of high Doppler rates, while the FT-847 and the TS-2000 do not. The TS-2000 and the IC-910H will accept internal modules for the addition of microwave bands, while the FT-847 will not. The TS-2000 has an internal TNC (Terminal Node Controller) for the packet modes, while the FT-847 and the IC-910H do not. All three radios accept computer control of frequency and mode; however, the interfaces are different. None of the three support digital data rates higher than 9k6 baud without modification. All three radios will support all of

Satellite News

Since the last column there have been no major meetings attended by this author and no new satellites launched. A Phase Three Express (P3E) meeting was held in Marburg, Germany on January 30, 2005. A report with pictures is available on the AMSAT-DL web page: <http://www.amsat-dl.org>. Several new launches are planned for the first half of 2005. Watch the AMSAT News Service Bulletins for announcements of these launches.

Figure 3. Block diagram of the AO-51 data rate mode L/S base station.



the basic AO-51 V- and U-band functions. All three radios can be used with internal or external accessories to support all functions except the highest data-rate mode.

Software Defined Radio technology currently offers the best hope of one radio to support all functions, but even this technology will work best with some external accessories. For example, uplink and downlink frequency conversions for the microwave bands are best done at or near the antenna. Receiver front ends (pre-amplifiers) are best placed at the antenna even on the V and U bands due to feedline-loss considerations.

Remember, if all you want to do on AO-51 is operate the V/U modes, a dual-band HT (or two single-band HTs) will suffice. Virtually all HTs will work, provided they cover or can be modified to cover the frequency range (70-cm band consideration). Full-duplex operation is desirable but not absolutely necessary. Even the digital modes are supported by the Kenwood TH-D7.

Most modern mobile, dual-band radios will support the basic V/U modes. The Kenwood TH-D700 is particularly good due to its built-in digital capability.

Antennas

For starters, the Arrow dual-band Yagi is very popular for working the V/U modes. It is possible to get by with even less on "QRP Day." If you want to seriously work the digital modes, I highly recommend circularly polarized Yagis for the V and U bands with Az/El rotors and mast-mounted pre-amps.

For the L and S bands it is easy to obtain a lot of antenna gain, but it's not so easy to keep the antennas pointed at a rapidly moving satellite. Small dishes, loop Yagis, and helicals work well. The S-band downlink is very strong, and even the feed from an AO-40–class dish has been used successfully.

Automatic antenna control is very desirable, especially for the digital modes, when you either want full automation or you are busy running the computer keyboard while the pass is in progress. To do automatic antenna control an interface between the computer and the antennal rotors is necessary. For years, the Kansas City Tracker was the most popular; however, it is now out of production and will not plug into the slots in newer computers. Rotator interfaces are now available to support both parallel and USB ports. Tracking programs such as Nova and SatPC32 do a good job with these newer interfaces.

Digital Interface

Last but not least, for full function capability the station must have a digital interface. This can be one of the older DSP-based modems or a TNC and a 9k6-baud (or higher) modem that supports the G3RUH protocol. A variety of this equipment is available, and I recommend acquiring a copy of the AMSAT Digital Satellite Guide to help choose and set up this capability. In the cases of the Kenwood TH-D7 HT, the TM-D700 mobile units, and the TS-2000 base station, the 9k6-baud capability is built in.

Summary

I hope I have not scared you off with the high-level discussion of station capabilities required to work AO-51 and other satellites. Remember, you can do it with an HT and an Arrow antenna, but for full function you need more. Also remember that the closer you come to equipping your station for all functions of AO-51, the better off you will be for future satellites such as SETI Express, P3E, and Eagle.

73, Keith, W5IU

By April Moell,* WA6OPS

VHF+ PUBLIC SERVICE

Amateur Radio and Community Service

Hospital Backup Communications Early Lessons Learned

A quarter-century ago, a switchboard failure led this author to realize the critical importance of communications in medical facilities. The special organization that I formed to serve this largely unfilled mission can serve as an example for your ARES/RACES group.
—WA6OPS

Mark Shapiro, K6OGD (center), is in the middle of the action as HDSCS participates in one of its first Orange County mass-casualty drills back in 1981. He is alerting the hospital command post of the arrival of patients by bus and ambulance. (All photos by Joe Moell, KØOV)

Think back to the last time you lost your home telephone service. It certainly was an inconvenience. You probably were concerned about missing a call from someone you care about. What if an emergency had happened? Then, too, loss of phones at a business is not only inconvenient, but it could have financial consequences: the loss of a sale, not getting an account, or being late in getting important information.

Now think about such a communications loss in a hospital, particularly one which provides acute and emergency care to the community. A failure of telephones in a hospital isn't just an inconvenience or a potential financial loss; it is a patient care emergency. Time-critical calls are placed between units and to physicians and services outside the facility every day.

Even though I had worked in the hospital environment for several years, I didn't appreciate this fact until the phones in my workplace failed in 1979. It didn't take an earthquake or other major disaster to suddenly put patients at risk due to a communications failure that day. It also didn't take a major disaster for amateur radio to become a key communications resource.

At the time, I was the Director of Occupational and Recreational Therapy at St. Jude Hospital in Fullerton, California. Because we live in earthquake country, my husband (Joe Moell, KØOV, editor of the "Homing In" column in *CQ VHF*) and I kept our radio equipment handy at work so we could quickly contact one another if the earth shook. My trusty Drake TR-33 was in my desk drawer and my ARES card was in my wallet. What training I had was as a result of performing Red Cross communications during some brush fires. The hospital had an HF ham station, used for "Rehab Radio" with patients as part of the hospital's rehabilitation programs. I was ready for an emergency . . . so I thought.

When I realized that the entire hospital had no working phones, I grabbed my TR-33 and headed for the administrator's office, thinking I could help. I quickly realized that I didn't really know what I was offering. The ham station in the basement would be of no help, being far from the switchboard and only on the HF bands. That wouldn't help with unit-to-unit communications nor with contacting the local physicians in their offices.

As I reached the administrator's office, the hospital's chief engineer was in the doorway. I showed my rig and offered, "Would you like me to get some radio operators in to help?" The administrator looked rather quizzically at me for a moment and then said, "Well, I'm not sure we need to do that." The engineer countered with, "Maybe it wouldn't hurt to let some of them come in." I looked over at the administrator and he nodded.

I quickly made my way through the front entrance and, outside the building, made a call on the ARES repeater. Fortunately, someone I knew answered from his home and volunteered to get help. All I could tell him was that the hospital had no phone service. I waited anxiously in front of the lobby entrance. Eventually, amateur radio operators started arriving, some having heard my plea on the radio and some having been called by the ham who first answered me.

The phones stayed down for about two hours. The radio operators arriving throughout that time had widely varied levels of preparedness. Many I knew. Some I didn't. Their radios served as their identification as I thanked them for com-

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ing and directed them into the hospital and on to the switchboard.

Some responders had only their big 1970s-vintage HTs, one brought in a pull cart with a mobile rig on it, and another had a large briefcase, like a salesman. For most of the outage the radio operators were busy trying to get communications established at hospital units that the switchboard operator deemed most important. One left the hospital after 20 minutes because his only HT battery had died. A few unit-to-unit messages were handled. Then the phones came back on line.

A Great Response, However ...

Hospital staff members were very impressed that volunteer radio operators could and would come to their facility to help in the middle of a weekday. However, I was breathing a sigh of relief, realizing that it was a rather haphazard response. Most operators on site, including me, weren't well prepared. It took too long to get reliable internal communications established. The operators weren't ready for an extended outage, if it had occurred. Also, except for me, no operator had any familiarity with the medical environment, other than perhaps as a former patient. For instance, I was a bit uncomfortable about the hams on a nursing unit not knowing what "stat" meant (it means "now"), and not having any idea what communications would be needed if a Code Blue (life-critical emergency) occurred.

At that point, I had little chance to think all of that through, because accolades had started to come my way. An article appeared in the local paper about what I had done with my radio to get ham operators to help, with a photo of me holding my TR-33 while standing in front of the hospital. I was quite pleased, because I had done what I had been told by ham leaders was important: "Get publicity for amateur radio."

The Emergency Department supervisor was quite intrigued by what had happened on the day of the phone outage. She came to my office, and I ended up presenting a tutorial on amateur radio to her. She was extremely interested in that, especially as I talked about ARES and how we had helped out in wildfires. I showed her articles from amateur radio publications about responses after tornadoes and hurricanes.

That same Emergency Department supervisor also served as the hospital's disaster coordinator. The next thing I knew, she was asking me to put a group of hams together to help the hospital in an upcoming Orange County disaster drill. My only involvement with disaster planning at that time was to prepare my department for what would happen in our area if a major mass-casualty incident occurred. Our rehabilitation rooms would become holding areas for early discharged patients and less-injured patients awaiting further treatment. My involvement was soon to change.

I contacted our area EC (emergency coordinator) at the time, Ralph Swanson, WB6JBI, to discuss what had happened. With his support, I selected seven ARES members to help. On the morning of the drill we all gathered in the east lobby, near the switchboard. That area became the hospital's Emergency Command Post as the drill got under way. Since I knew the facility, I then escorted each ham to locations requested by the disaster coordinator.

The simulated scenario began. Notification of incoming ambulances came via landline and a newly installed coun-

ty-wide VHF voice and signaling system known as HEAR, the Hospital Emergency Administrative Radio. Within an hour St. Jude was receiving a large number of victims from the simulated disaster scene. As employees acted out real-time use of the Emergency Department, X-ray, Laboratory, and Surgery suites, the hams relayed important information between key locations. Our ham outside of the Emergency Department door proved to be a big help, because he provided ambulance arrival information that the command staff had not been able to rapidly ascertain in previous drills.

Soon over 20 drill patients were in the facility, and more were coming. A bottleneck developed in the hallway outside of Surgery, where there was no telephone. I was asked about putting a radio operator in that location to communicate directly with the Emergency Department. My facilitator/oversight role suddenly disappeared. I reported to the Surgery desk. A nurse quickly joined me, and we went into the hallway by the elevator. The Emergency Department communicator was asked to inform us any time there was a decision to send a patient down to Surgery.

On numerous occasions the medical staff used third-party communications on our radios, deciding whether a patient needed to come directly to Surgery, could be temporarily taken to the Intensive Care Unit, or should be brought into the Recovery Department and monitored until a surgical suite became available. This made a huge improvement in getting the overload of patients prioritized. Surgery staff members were thrilled.

We all learned a great deal that day. The hospital learned that hams are a communications resource that can be deployed where needed most inside the hospital. The hams learned what it was like to work directly with hospital staff and how an understanding of the medical environment is crucial to best provide communications related to patient care. Although the hospital leaders were impressed with our effort, we realized that to become an integral part of the disaster plan more education and training would be a must.

From One to Seven

Orange County Emergency Medical Services Agency geographically divides hospitals into color-coded response groups for disaster planning. Representatives of hospitals and fire/paramedic agencies in each group meet regularly to plan their required mass-casualty drills and to critique them. Seven hospitals in north Orange County, including St. Jude, made up the Brown Net grouping in 1980.

Pleased with our drill performance, St. Jude's Disaster/Safety Coordinator asked me to come to the next Brown Net Disaster Committee meeting to talk about what had happened in the phone outage and what we did in the drill. Once again, I was ready to wave the banner of amateur radio, but I still had not quite grasped the bigger picture. With great enthusiasm, I touted the value of amateur radio in the aftermath of disasters such as the 1964 Alaska earthquake and recent tornadoes in the Midwest. Then I described the phone outage and what we did in the drill. Every hospital representative in attendance had questions, but the question that launched me on a 25-year path was "We don't have an April working at our hospital. How do we get hams when we need them?"

Surrounding Orange County Board of Supervisors Chair Bill Campbell (holding the proclamation) are HDSCS members attending the 2005 Orientation and Review Workshop. To the left of Supervisor Campbell is Jay Thompson, W6JAY, winner of Newsline's Young Ham of the Year 2003 and ARRL Hiram Percy Maxim Award 2004. Jay has been a member of HDSCS since 2000. To the left of W6JAY is April Moell, WA6OPS. Standing at the far right is Ralph Swanson, WB6JPI, a charter member of HDSCS who was ARES EC for Orange County when the group was formed.

As the meeting ended, all seven hospital representatives wanted amateur radio operators to be on call for their facilities. The disaster coordinator from a hospital at the eastern boundary of the county, along the banks of the Santa Ana River and downstream from Prado Dam, had an even greater concern. "We're pretty far away from the major part of the county," he said. "Who will think of helping us in an earthquake or other disaster when all the phones are out? We have the new HEAR radio, but sometimes it goes down and it certainly could be inoperable after an earthquake."

I realized that I had just done a great sales pitch, but I didn't really have a "product" to provide. I wasn't prepared to tell these hospitals just how amateur radio would support them, so I started by giving them my name and phone numbers and said I would get back to them with a plan. In the meantime, they could call me in the event of a communications problem.

I wasn't very comfortable with that response. What if I wasn't around when communications failed? If I got an emergency call, was I going to just jump on the repeater again and ask for help? Yikes! What if it was at 2 AM? Would I know the responding hams? Would they be prepared? How would we be activated by hospitals if there was an earthquake and all the phones went down?

I asked for a follow-up meeting with the ARES area EC to explain what I was being asked to do. He quickly appointed me as an assistant EC to organize a response plan for the requesting hospitals. We had already learned some lessons that would start us on our planning, but the "How do we get hams?" question troubled me. The other question, "Who will think about our hospital in a major disaster?" bothered me even more.

My own hospital had an HF station and I had my 2-meter radio with me on the day we lost our phones. However, just having some equipment at hospitals would not constitute a plan. Finding hospital employees with an amateur radio license wouldn't be an adequate plan either. I'd already encountered one hospital employee with a ham license, but he wasn't active in the hobby and had no equipment at the time. We had known about the drill well in advance, and the hams were already on site at the start of the simulation. That didn't test how we would be activated for an actual mass-casualty incident, nor did it test what it would be like to activate, get into the hospital, and get started in real time.

County of Orange

Hospital Disaster Support Communications System Volunteers

25 YEARS OF SERVICE TO ORANGE COUNTY

__WHEREAS__, the Hospital Disaster Support Communications System is a specialized entity of the Amateur Radio Emergency Service (ARES) in Orange County; the Amateur Radio Emergency Service is the national public service and emergency communications branch of the American Radio Relay League (ARRL), which is the largest national association of Amateur Radio devotees, and

__WHEREAS__, a disruption in telephone service at a large hospital in Fullerton in 1979 and the remarkable and inspiring reaction of the Amateur Radio operators to that emergency was the impetus led to the creation of the Hospital Support Communications System, which commenced operations twenty-five years ago; and

__WHEREAS__, the Hospital Disaster Support Communications System began with seven support facilities and has expanded to encompass all of the acute care receiving hospitals in Orange County and other critical medical facilities, and

__WHEREAS__, all members of the Hospital Disaster Communications System are FCC-certified Amateur Radio operators who have their own portable radio equipment ready to respond to nearby hospitals; member equipment preparedness is imperative because almost all HDSCS activations entail backup of communications among entities within the facility, and

__WHEREAS__, HDSCS volunteers provide important and valuable services to the people of Orange County; they work diligently to ensure that emergency personnel are able to maintain communications during disasters and crises; and

__WHERRAS__, the efforts of HDSCS volunteers allow for staff, suppliers, and outside organizations, such as blood banks, the American Red Cross, and county Emergency Medical Services agency to maintain their communications ability, and

__WHEREAS__, HDSCS supports thirty-four hospitals and health care facilities throughout Orange County by maintaining regular contact with them to ensure that they will be able to cooperate with each other and coordinate each of their individual communications and disaster plans during a crisis; and

__WHEREAS__, HDSCS volunteers have the capability to provide both internal and external communications when telephone service disruption occurs; and

__NOW, THEREFORE BE IT PROCLAIMED THAT SUPERVISOR BILL CAMPBELL__ does hereby recognize the Hospital Disaster Support Communication System Volunteers for their 25 years of dedicated service to the residents of Orange County and offers his sincere best wishes for their future endeavors.

March 5, 2005

Bill Campbell

BILL CAMPBELL
Chairman of the Board
Supervisor, Third District

This proclamation from the Orange County Board of Supervisors was recently presented to HDSCS in recognition of 25 years of service to the citizens.

Orange County ARES needed a robust activation procedure for the hospitals. I was around much of the time, but not 24/7/365. There had to be persons in addition to me as primary points of contact. Whom could I rely on to come help at a hospital? Having been through the phone outage, I knew well that there was a wide range of preparedness, knowledge, and experience among hams. Being a patient care person, I knew the hospitals' concerns for privacy. I also knew that a hospital is a specialized and technical environment. It was obvious that education would be important for radio operators wanting to help there, to avoid mistakes or misunderstandings. In a hospital, PTT does not mean "push to talk." "Quad" does not refer to an antenna.

The early lessons had indeed been learned and now it was time to get to work. A special group of amateur radio operators interested in this aspect of the Amateur Radio Emergency Service had to be formed. An activation procedure had to be devised for each hospital to use. Response to multiple hospitals in major area-wide disasters had to be planned. Training had to take place so that responders would be prepared and knowledgeable.

There was plenty to do, but little did anyone realize what lay ahead. We had far more yet to experience, learn, and accomplish.

Fast-Forward to 2005

The Hospital Disaster Support Communications System (HDSCS), a special ARES group, now has agreements to provide backup communications for all of the acute receiving centers and some other specialty hospitals that are part of Orange County's mass-casualty plan. We have participated with hospitals in communications drills 136 times. On 86 occasions since the first time in 1979, we have stepped in to provide communications when telephones failed or became overloaded in isolated and area-wide emergencies.

The yearly HDSCS Orientation and Review Workshop has just concluded as I write this. This all-day session takes place on a Saturday at the county's Emergency Operations Center. Basic concepts and procedures are reviewed, and detailed information about functioning as a communicator in the hospital environment is presented. We also teach basic personal and equipment preparedness as members bring in their disaster "Go-Kits" for show-and-tell.

The workshop is always a great day of learning, camaraderie, and good food at the "disaster potluck." However, this year was a bit different, as we celebrated the 25th anniversary of the establishment of HDSCS. In previous years, HDSCS has been honored at our workshop and other events by visits and award presentations from mayors, county officials, state legislators, and U.S. Congressmen. This year there was something more. Employees from several hospitals made a non-workday trek to the EOC just to say thank you to the group for their continued service in phone outages, the 2003 Placentia train collision, earthquakes, and so forth.

Huntington Beach Hospital staff and a physician arrived with a huge cake and special plaque. Our support was particularly fresh in their minds, because six weeks before HDSCS had responded to a power and phone outage caused by a nearby traffic accident that downed a power pole. For over three hours we kept critical units within the hospital in constant contact. A few staff members had cell phones and business-band walkie-talkies, but they still wanted, used, and appreciated their amateur radio resource.

The emergency communications needs of hospitals are different in many ways from those of Red Cross, SKYWARN, and other agencies that ARES traditionally serves, but hospitals' communications are no less important than communications for any of them. In future installments of this series, I will have much to say about alerting plans, equipment and personal preparedness, effective drills, and other special considerations for medical communications support. Start thinking and planning how your club or ARES or RACES group can respond quickly and effectively when a communications emergency puts patient lives at risk. 73, April, WA6OPS

About the Author

April Moell, WA6OPS, is founder and leader of the HDSCS, a 75-member group that provides emergency backup communications for 34 medical facilities in Orange County, California. She presents this series of articles in the hopes that hams around the country will take on the important mission of providing rapid-response support for every hospital in their hometowns. More information about HDSCS is at <www.hdscs.org>.

By Kent Britain,* WA5VJB

ANTENNAS

Connecting the Radio to the Sky

Cheap Yagis for 2450 MHz

This time, at the suggestion of one of our readers we take the Cheap Yagi construction projects to 2450 MHz (photo A). While this is not the highest frequency for which I have built a Yagi (that is still 10,300 MHz), it is the highest frequency for a "Cheap Yagi" construction project.

The design was more challenging than I had thought it would be. I try to keep all dimensions to .1 inch accuracy. Yes, I've seen published 20-meter beam designs with dimensions to .0001 inch, but that's ridiculous. Also, the 2.4-GHz ISM (Industrial, Scientific, and Medical) band is 83 MHz wide. That is pretty wide for a long Yagi, but after several tries I have two Cheap Yagis that fit the bill.

When things get small, little things become big things. Just how the ends of the elements are cut makes a difference (figure 1). My prototype wouldn't tune up until I cleaned up the jagged ends of the elements. A few quick strokes with a flat file—or in my case, a second on the belt sander—fixed the problem. The antennas covered here have similar dimensions (figure 2 and Table I), and

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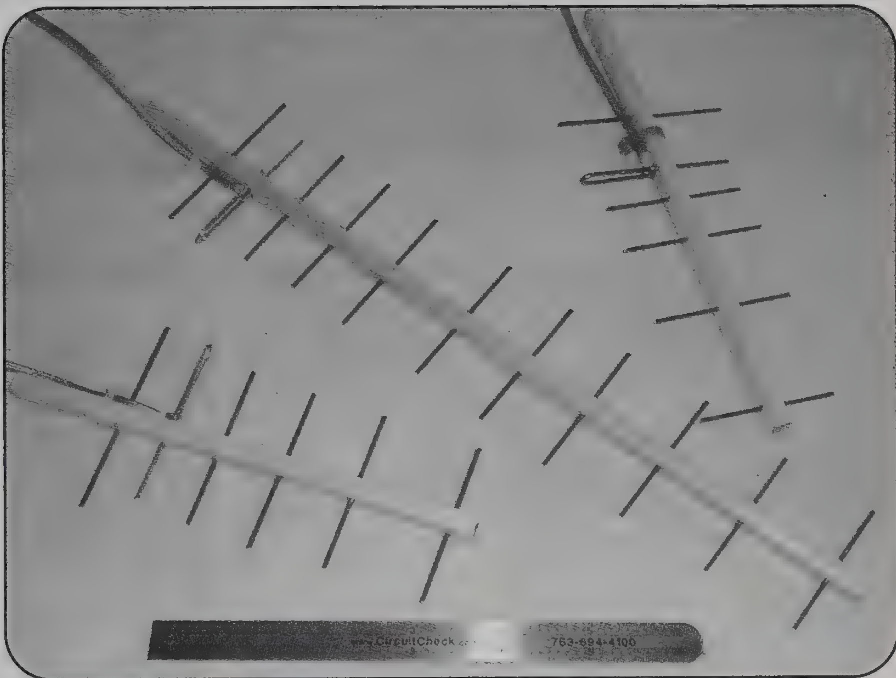

Photo A. 2400-MHz Cheap Yagis.

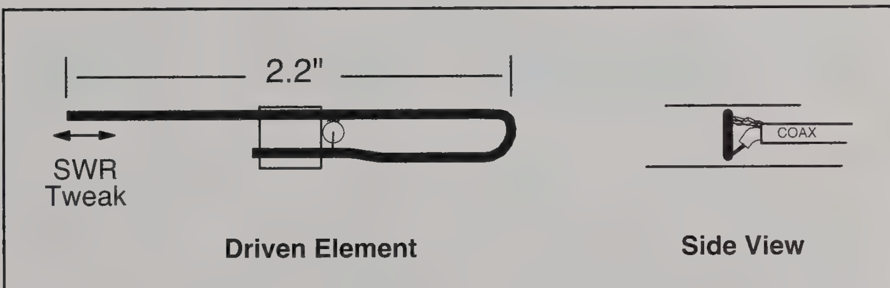

Figure 2. Driven element of both the 6-element and 11-element versions.

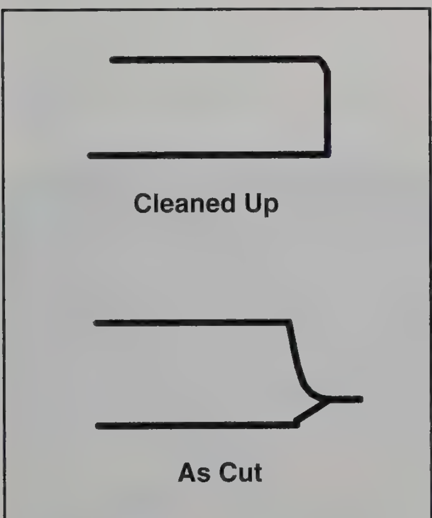

Figure 1. Element ends.

	Ref	DE	D1	D2	D3	D4	D5	D6	D7	D8	D9
6 elements											
Length	2.4	*	2.1	2.1	2.0	1.9	—	—	—	—	—
Spacing	0	.6	1.3	2.1	3.0	4.2	—	—	—	—	—
11 elements											
Length	2.4	*	2.1	2.1	2.0	2.0	2.0	1.9	1.9	1.8	1.8
Spacing	0	.6	1.3	2.1	3.0	4.2	5.2	6.2	7.3	8.5	9.8

Driven element is per figure 2 for both Yagis.

Table I. Dimensions (in inches) of the 6-element and 11-element Cheap Yagis.

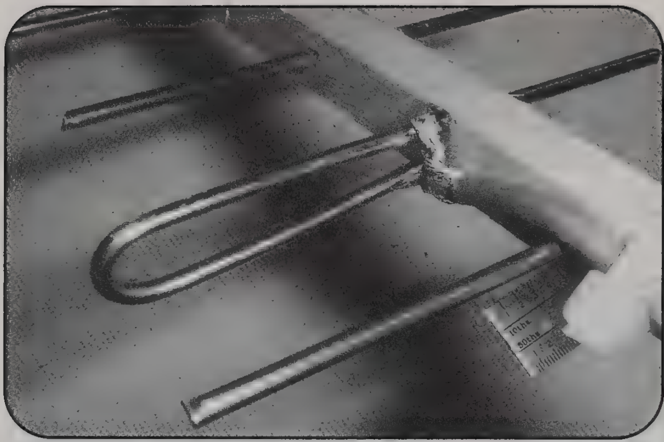

Photo B. The driven element.

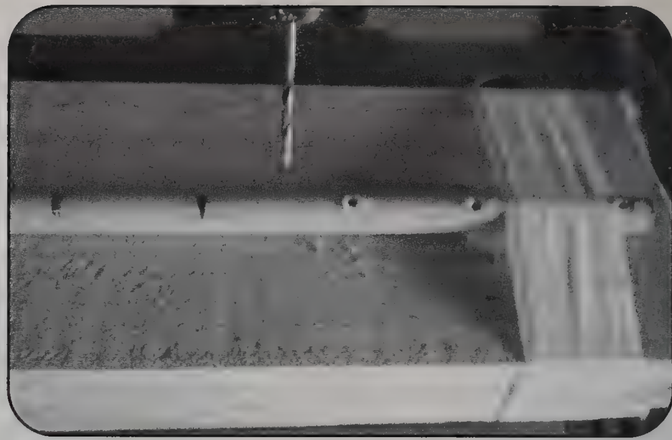

Photo C. Dowel drilling.

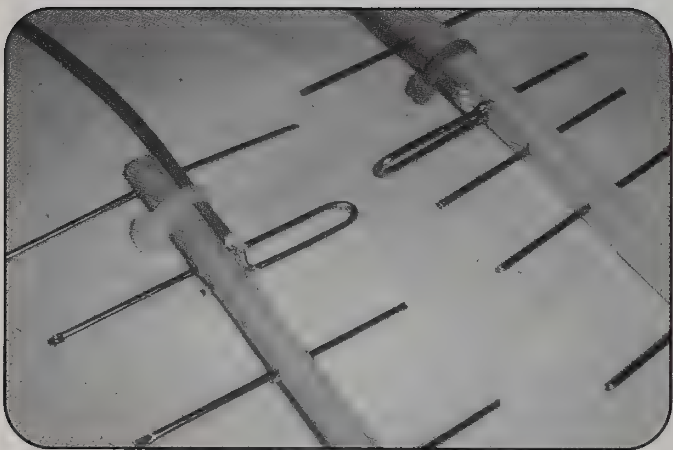

Photo D. Rotated driven element.

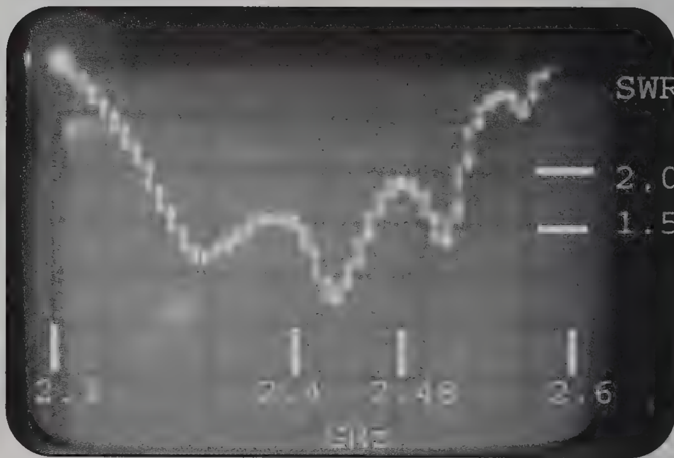

Photo E. Network-analyzer plot of the 11-element antenna.

that was not by accident. For the sake of simplicity, I forced the designs to converge. There is no real loss in performance, but it did take a bite out of my sanity to get to that point.

Construction

All elements are 1/16-inch material. I used silicon bronze welding rod, but 14-gauge copper wire or any .062-inch diameter rod can be used (photo B). A drop of Super Glue® was used to hold the elements in place. For my prototypes I used 1/4-inch-square wood from the local home-improvement store, as it's much easier to drill.

If you do insist on using 1/4-inch dowel, taping it to a block of wood makes it much easier to drill the elements in a straight line (photo C). You also will need to use a lot of glue to hold the driven element in place, or flip it 90 degrees when using dowel (photo D). There are several technical reasons for not wanting to flip the driven element. It creates quite a bit of uncertainty as to exactly where the phase center of the element is. However, it can be done. Note the flipped driven element on the PC-board version later on.

The shield of your 50-ohm coax goes to the center of the driven element. The center of the coax goes to the inter tip of the J element. Yes, they are offset slightly and not exactly in the center of the J, but that has been allowed for in the final dimensions. The bend in the end of the J is going to end up .2 to .25 inch wide just so it will go back into the boom. The radius of the bend, and the distance between the tip and body of the J are not a critical dimension. Just make it fit and you'll be okay. If you have the equipment to measure return loss or SWR at 2.4 GHz, the free tip of the J can be trimmed for best SWR (photo E).

Performance

While the Yagi does cover the entire 83 MHz of the ISM band, it does work a bit better in the ham portion of the band

Photo F. "But I built it exactly to your dimensions!"

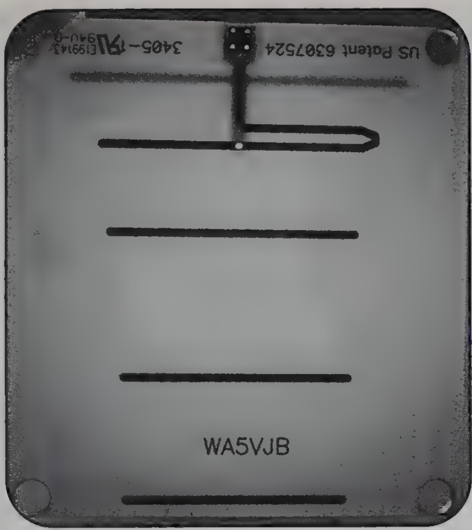

Photo G. A 5-element Cheap Yagi etched on PC board.

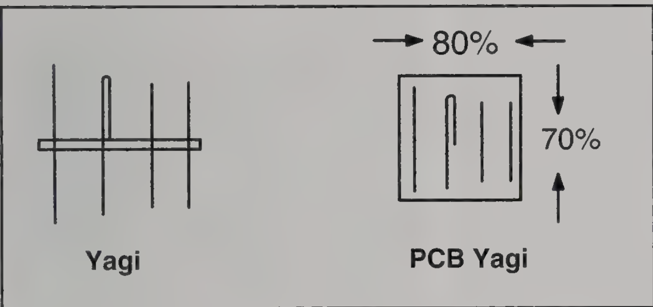

Figure 3. Free-space Yagi and PC-board Yagi.

and has good performance in the AMSAT portion. How about this antenna for a small S-band AMSAT station? Gain varied over the band, but ran between 12 and 13 dBi for the 11-element antenna and 9.5 to 10.5 dBi for the 6-element version.

Wood

Since wood doesn't conduct electricity, many seem to assume it has no effect on the antenna. Well, that's not entirely true (photo F). Wood contains cellulose and moisture, and these give the wood an E_r, or dielectric constant.

When light travels through water or glass, it travels more slowly. The same is true when a radio wave travels through plastic, air, wood, etc. The E_r of wood varies quite a bit between dry balsa wood and damp teak, but through typical construction woods, the radio wave travels at about half the speed it does in air. Wood around a wire is a bit more complex, and the effect varies greatly with wavelength. However, for 1 inch of wood you need to make the element about one-tenth inch shorter to allow for the effects of the wood. That's no big deal on 2 meters, but above 400 MHz or so a very thick boom can kill a Cheap Yagi. Now just put the Yagi in/on a dielectric material, and you quickly learn about E_r effects.

A Cheap Yagi Etched on PC Board

Photo G shows a Cheap Yagi etched on PC board. Taking the photo was not a lot of fun, since there are elements on the top and bottom of the board, but the back lighting shows the elements well.

Thus far I have developed nine different PC-board Cheap Yagis from 434 MHz to 5800 MHz with over 10,000 of the 915-MHz versions in the field. In general, start with a design for a free-space Yagi (figure 3). Shorten the elements about 30% and reduce the element-to-element spacing about 20% when you generate the PC-board artwork. These are general factors, and that .062-inch thick PC board looks a lot thicker to a 11-GHz radio wave than it does to a 400-MHz radio wave (photo H). Also, the E_r of the fiberglass tends to drop as you go up in frequency. While the fiberglass board may have a E_r rating of 4.0, that is usually measured at 1 MHz and drops to 3.7 or 3.8 in the GHz range. All these factors really cause problems when designing PC-board log-periodic antennas from 400

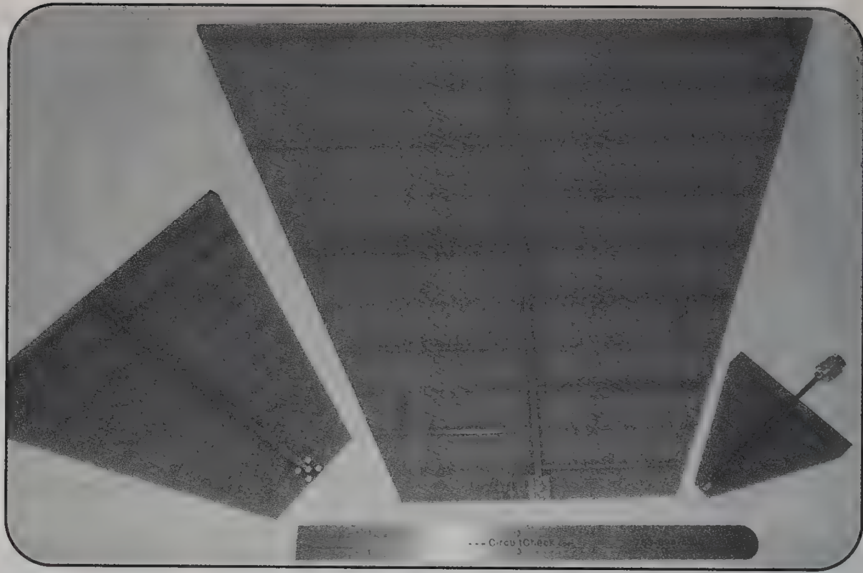

Photo H. PC-board log-periodic antennas from 400 MHz to 11 GHz.

MHz to 11 GHz. In my case, there is a big box of prototypes in the shack with trimmed elements that just weren't quite right. However, once you get the dimensions right, thousands and thousands of high-quality antennas can be etched with high repeatability.

I've been asked many times what computer program I use to design PC-board antennas. To the best of my knowledge, there is no program for designing them. For IE3D, HFSS, SONNET, etc., users, you can use all that computing horsepower to analyze an existing design, but those programs do not design the antenna for you. These programs also require you to know things that you rarely know, such as the E_r of the PC-board material over an octave of frequency.

Last, I don't have the space here to explain, but you *cannot* accurately frequency sweep log periodics with these programs. I'm waiting for the e-mails to come pouring in, but you cannot accurately frequency sweep a PC-board log periodic antenna with these programs. This is a road I and others have been down!

Are you planning to be at the Dayton Hamvention®? If the timing belt on my car doesn't break, I should be in slot 915 selling 915-MHz PC-board antennas. I'll be happy to show you some of the 200-plus 13 MHz to 11 GHz antennas that I have designed.

E_r for Quad Builders Bare Wire vs. Insulated Wire

Making that quad antenna designed for bare #12 copper wire out of insulated #12 copper wire moved it down in frequency about 5%, didn't it? Your 147-MHz quad resonates in the 130s, and the element spacing now is all wrong. You can compensate for this. Make the elements about 95% as long, but the smaller elements won't couple quite as well, so the element-to-element spacing has to be changed as well. In theory, all of this can be incorporated into the new design—that is, when you know the E_r of the plastic (see main text below)! Just try going down to the local hardware emporium and asking the clerk for the E_r of the #12 insulation when measured at 147 MHz. Be prepared for that "deer in the headlights" stare. The electrical wire insulation materials are optimized for voltage puncture, UV exposure, moisture resistance, flexibility, etc. The dielectric constant of the insulation is not controlled from batch to batch or manufacturer to manufacturer. Thus, a quad design using insulated wire might not be able to be replicated by others.

Next Time

Next time I'll cover why you don't want to use a 1/4-wave antenna with those new RF transceiver chips from Chipcon, RFM, Micrel, etc. This applies to many ham rigs as well. I'm also trying again to come up with a 6-meter Cheap Yagi. It's a mechanical, not an electrical, problem.

As always, some of my best ideas for this column come and from your e-mails and questions.

73, Kent, WA5VJB

QUARTERLY CALENDAR OF EVENTS

Contests

May: Spring Sprints. These short duration (usually four hours) VHF+ contests are held on various dates (for each band) during April and May. May's dates and times are as follows: Microwave, May 7, 6 AM to 1 PM local time; and 50 MHz, May 14, 2300 UTC Saturday to May 15, 0300 UTC Sunday. Sponsored by the East Tennessee Valley DX Assn., more information can be found at <http://www.etdxa.org>. Click on the VHF/UHF link.

The **2 GHz and Up World Wide Club Contest**: Sponsored by the San Bernardino Microwave Society, this contest runs from 6AM on May 7 to 12 midnight on May 8 (36 hours). The object is for worldwide club groups of amateurs to work as many amateur stations in as many locations as possible on bands from 2 GHz through Light. Rules are at: <http://www.ham-radio.com/sbms/club_contest/2GHzUp.pdf>.

The **Six Meters Marathon 2005** is open to all amateur radio operators worldwide. The objective is to work as many DXCC entities as possible on 6 meters between 7 May (0000 UTC) and 7 August (2400 UTC). Results will be continuously updated at <http://www.50mc.tk>. For details contact Hannu Saila, OH3WW, e-mail: <marathon@saila.org>.

June: **European Worldwide EME Contest**. Sponsored by *DUBUS* and REF. The EU WW EME contest is intended to encourage worldwide activity on moonbounce. Multipliers are DXCC countries plus all W/VK/VE states, giving equal chances for stations from N. America, Europe and Oceania. The rules reward random QSOs, but do not penalize skeds on 2.3 GHz or above. Winners (1st places) receive a free subscription to *DUBUS* magazine. The contest dates and bands are as follows: Second weekend: 144 MHz, 2.3 GHz, and 3.4 GHz, 14-15 May, 0000 to 2400 UTC; and third weekend: 432 MHz and 5.7 GHz, 11–12 June, 0000 to 2400 UTC. Contest entries *must* be sent no later than 28 days after the end of the third weekend (i.e., in the mail or e-mail by July 10, 2005). Mail address: Patrick Magnin, F6HYE, Marcorens, F-74140 Ballaison, France. You can also e-mail your contest entry in ASCII format to: <f6hye@ref-union.org>. For additional rules and general questions contact: <info@dubus.de>. Complete rules can be found at: <http://www.marsport.demon.co.uk/EMEcont2005.pdf>.

Six Club Contest: The Major Six Club Contest is anticipated to be the first weekend in June, 2300 UTC, June 3 to 0200 UTC, June 6. These dates need to be confirmed by the sponsor. All logs are due 30 days from ending date of the contest and they go to <w4wrl@aol.com>. For further information go to: <http://6mt.com/contest.htm>.

ARRL June VHF QSO Party: The dates for this contest are 11–13 June. Complete rules are in the May issue of *QST* and on the ARRL website (http://www.arrl.org). For the latest information on grid expeditions, check the VHF reflector (vhf@w6yx.stanford.edu). For weeks in the run up to the contest, postings are made on the VHF reflector announcing Rover operations and grid expeditions. This is a great opportunity to introduce the hobby and the VHF+ bands to your friends.

SMIRK 2005 QSO Party: Sponsored by the Six Meter International Radio Klub, this will be held 0000 UTC June 18 tol 2400 UTC June 19. It is a 6-meter only contest. All phone contacts within the lower 48 states and Canada must be made above 50.150 MHz; only DX QSOs may be made between 50.100 and 50.150. Exchange SMIRK number and grid square. Score 2 points per QSO with SMIRK members and 1 point per QSO with nonmembers. Multiply points times grid squares for final score. Awards are given for the top scorer in each ARRL section and country. Send a legal-size SASE for a copy of the log forms. Log requests and logs (send entries by August 1) should be sent to Pat Rose, W5OZI, P.O. Box 393, Junction, TX 76849-0393. For more info go to: <http://www.smirk.org>.

Quarterly Calendar

May 1	Moderate EME conditions
May 8	New Moon Moderate EME conditions
May 14	Moon apogee
May 15	Good EME conditions
May 16	First Quarter Moon
May 22	Moderate EME conditions
May 23	Full Moon
May 26	Moon Perigee
May 29	Moderate EME conditions
May 30	Last Quarter Moon
June 5	Poor EME conditions
June 6	New Moon
June 11	Moon Apogee
June 12	Good EME conditions
June 15	First Quarter Moon
June 19	Moderate EME conditions
June 21	Summer Solstice
June 22	Full Moon
June 23	Moon Perigee
June 26	Good EME conditions
June 28	Last Quarter Moon
July 3	Poor EME conditions
July 6	New Moon
July 8	Moon Apogee
July 10	Moderate EME conditions
July 14	First Quarter Moon
July 17	Poor EME conditions
July 21	Full Moon and Moon Perigee
July 24	Very Good EME conditions
July 28	Last Quarter Moon
July 31	Poor EME conditions
August 4	Moon Apogee
August 5	New Moon
August 7	Moderate EME conditions
August 13	First Quarter Moon
August 14	Poor EME conditions
August 19	Full Moon and Moon Perigee
August 21	Very Good EME conditions
August 26	Last Quarter Moon
August 28	Very poor EME conditions

—EME conditions courtesy W5LUU

Field Day: ARRL's classic, Field Day, will be held on June 25–26. Complete rules can be found in *QST* and at <http://www.arrl.org>. In years past tremendous European openings have occurred on 6 meters. Also, as happened in 1998, great sporadic-*E* openings can occur. This is one of the best club-related events to involve new people in the hobby.

July: **CQWW VHF Contest**. This year's CQ WW VHF Contest will be held from 1800 UTC July 16 to 2100 UTC July 17. Complete rules can be found elsewhere in this issue on page 58.

The **Mid Summer Six Club Contest** is expected to be held from 2300 UTC, July 15 to 0300 UTC, July 17. These dates need to be confirmed by the sponsor. All logs are due 30 days from ending date of the contest and go to <w4wrl@aol.com>. For more info go to: <http://6mt.com/contest.htm>.

August: The **ARRL UHF and Above Contest** is scheduled for 6–7 August. The first weekend of the **ARRL 10 GHz** and above cumulative contest is scheduled for August 20–21. The second weekend is September 10–12. Complete rules for both contests can be found in the July issue of *QST*.

Conventions and Conferences

May: The 2005 **West Coast Space Symposium** will be presented by Project OSCAR and The College of San Mateo May 7th in San Mateo, California. Topics include: Satellite Basics, Software Defined Radio, Digital Modes on Amateur Satellites, Satellite Tracking, Dish Feed Designs, 10 GHz and Above, Amateur Radio on the ISS, Orbital Debris Mitigation, Satellite Launch Options, and Youth and Amateur Satellites. Donation $15; Students $8 (includes lunch and parking). Registration starts at 8 AM. Presentations start promptly at 9:00AM. Talk-in frequencies 7–9 AM on 147.300+ and 441.950+ PL 100. Additional information: <http://www.ProjectOSCAR.net>.

Dayton HamVention®: The Dayton HamVention® will be held at the Hara Arena in Dayton, Ohio, May 20–22. For more information, go to: <http://www.hamvention.org>. Your editor is scheduled to be a speaker at the VHF forums.

June: **Ham-Com**. The annual Ham-Com Hamfest will be held June 3–5 in Arlington, Texas. The North Texas Microwave Society will present a microwave forum. For more information, see the Ham-Com website at <http://www.hamcom.org/>.

July: This year's **Central States VHF Society Conference** will be held July 28–31 at the Sheraton Hotel, Colorado Springs, Colorado. For more information, go to: <http://www.csvhfs.org>.

Calls for Papers

Calls for papers are issued in advance of forthcoming conferences either for presenters to be speakers, or for papers to be published in the conferences' *Proceedings,* or both. For more information, questions about format, media, hardcopy, email, etc., please contact the person listed with the announcement. To date this year the following organizations or conference organizers have announced calls for papers for their forthcoming conferences:

The 39th annual **Central States VHF Society Conference**, July 28–31 at the Sheraton Hotel, Colorado Springs. The deadline for submitting final papers will be around May 31. Submit your papers and your desire to make a presentation as soon as possible to Technical Program Chair Joe Lynch, N6CL, at <n6cl@sbcglobal.net>.

TAPR/ARRL Digital Communications Conference: Technical papers are solicited for presentation at the 24th Annual ARRL and TAPR Digital Communications Conference to be held September 23–25 in Santa Ana, California, and for publication in the conference *Proceedings.* Presentation at the conference is *not* required for publication. Submission of papers is due by August 9th. Send to: Maty Weinberg, ARRL, 225 Main St, Newington, CT 06111; or via e-mail: <maty@arrl.org>.

Microwave UpDate: The following is from Chip Angle, N6CA, Technical Program Chairman: The 2005 Microwave UpDate will be held this year in the Los Angeles area October 27–31. Interested authors are invited to present a paper(s) for the 2005 conference. You don't have to give a talk to have your paper included in the conference *Proceedings.*

(Continued on page 71)

By Joe Moell,* KØOV

HOMING IN

Radio Direction Finding for Fun and Public Service

Transmitter Hunting—A Youth Magnet

"For its future health, amateur radio needs more newcomers, especially young people." You probably have heard and read that opinion often. Chances are you have expressed it yourself. Better yet, maybe you are acting on it.

Hats off to the hams who talk up and teach ham radio in schools, Scouting, and other organizations for youth. Getting kids on the air, explaining about radio propagation, building code oscillators, and sending Morse code are some of the traditional techniques that have worked for decades. For the most part, these are classroom activities. Wouldn't it be ideal to include an outdoor ham-radio-related activity that exercises kids' bodies as well as their minds?

I believe that to get youngsters excited about our hobby there's nothing better than on-foot hidden transmitter hunting, also called foxhunting, foxtailing, and radio-orienteering. It combines good physical exercise with the technical challenge of using radio gear. There's the intrigue and adventure of discovering hidden objects with radio direction finding (RDF), plus the challenge of navigating with a map and compass. It lets kids express their natural competitive urges.

Jamboree-on-the-Air, an annual national Scouting event on the third weekend of October, is an ideal time to introduce Scouts to foxhunting.[1] There are also other Scouting events where amateur radio and transmitter hunting can play an important role. Some hidden transmitters in the trees would make a great activity for any Camporee.

Art Goddard, W6XD, arranged for an amateur radio display at a Scout-O-Rama in Long Beach, California during June 2003. That was the start of what has become an annual tradition. Art wisely suggested that the display include a variety of ham activities, including transmitter hunting.

Southern California Scout-O-Ramas are a sort of "activity fair" where Scouts learn from other Scouts about specialized activities of their troops, such as rockhounding and the Pinewood Derby. Non-Scout organizations such as ham radio clubs are allowed to display at the discretion of the Scout Council. It requires a large city park to hold it all.

The annual Long Beach Scout-O-Rama now features a virtual five-ring circus of amateur radio activities, including QSOs, emergency communications (see sidebar), CW, and transmitter hunting. Scouts receive a certificate for completing any activity, with endorsements for each additional activity, all counting toward their amateur radio merit badge.

It took five of us just to keep up with the interest in foxhunting at the 2004 event. Helping me were Marvin Johnston, KE6HTS; Jay Thompson, W6JAY; Richard Thompson, WA6NOL; and Tom Gaccione, WB2LRH. We placed seven


Certificate of Accomplishment

presented to

in recognition of participation in the following activities:

Visit Approved Amateur Radio Station
Two-Way Contact via Amateur Radio
Simulated Emergency Communications
Amateur Radio Transmitter Hunt
Send Name Using International Morse Code

Scout-O-Rama June 5, 2004
Heartwell Park, Long Beach, CA

ARRL Amateur Radio www.arrl.org

Amateur Radio Operator

This certificate, initialed and signed by the display activity leaders, helps Scout-O-Rama attendees qualify for a radio merit badge.

low-power transmitters out of sight within 100 yards of the display. All were on different frequencies in the 2-meter band. Each of us accompanied Scouts, usually two of them at a time, as they learned RDF and tracked down a fox or two.

I usually introduce kids to foxhunting by asking if they have seen nature specials on TV, where researchers follow the movements of radio-tagged animals. The idea of learning to do tracking like that appeals to them. I tell older kids about how RDF locates downed aircraft and mariners in distress.

I show them the 2-meter beam antenna and tell them how it's like the TV antenna or satellite dish on their roof, because it has to be aimed at the transmitting station to get a good picture. When it's aimed that way, we then know the direction to the station.

You probably have forgotten how difficult it is to hold onto even a medium-weight object for a while when you are eight years old. Thus, the lighter the RDF set, the better. If possible, the antenna should be balanced so that it rests on the hand and arm instead of pulling the wrist down. A Yagi with hand grip behind the reflector is fine for an older Scout, but in the hands of a grade-schooler it will tend to droop so that it points to the ground instead of out towards the horizon.

One-piece assemblies of antenna, attenuator, and receiver are easiest for adults, especially when dealing with maps. However, it may be better for a child to carry the radio in one hand and the antenna in the other, to balance the weight.

It's possible to get bearings by turning the beam and observing the quieting of an FM signal, but that's not intuitive for chil-

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e-mail: <k0ov@homingin.com>

dren. They will catch on much faster with an S-meter of some kind. The one on your handie-talkie is okay, but it forces the Scout to keep eyes on it instead of watching where he/she is going and looking for the foxbox. Audible signal-strength indication is better.

A tone-pitch S-meter makes it easy for both you and the Scout to know the direction of greatest signal intensity as you walk along, especially if the audio tone comes out of a speaker. Headphones are less desirable in that respect, although I have successfully used split earphones, one for me and one for the Scout. As long as we stay close and don't get tangled in the cords, it works. However, I prefer the speaker.

It isn't necessary for the beginner foxes to transmit continuously. Save batteries and make the hunt more interesting by programming the foxes to be on for about 7 seconds and then off for about 15 seconds.

With an audio-pitch S-meter it may be helpful for the helping ham to carry a separate HT tuned to the fox frequency, so both of you will know without a doubt when the fox turns on and off. I exclaim "It's on!" when the transmission starts, to alert the Scout and impart a sense of urgency about immediately getting a bearing. That gets him or her more and more excited as the hunt progresses.

After being instructed that they should hold the antenna straight out and turn their bodies to get the bearing, most kids will tend to turn 90 degrees or so as the signal increases, then stop. You probably will have to remind them several times to turn all the way around before they get into the habit. Teach them to turn past the point of maximum signal, then sweep back and forth to detect the exact point of maximum strength.

The older they are, the faster the kids will catch on. Some 7-year-olds won't get the hang of it at all. Others will naturally have the knack. They will catch on to RDF immediately, find the first fox quickly, and be eager for more. They will do even better the second time; you may not need to help out at all.

Don't pass up the opportunity to explain RDF technology when appropriate, using very simple terms. Scouts sometimes ask why an antenna with metal pieces of different lengths is directional, transmitting (and receiving) most of the radio energy forward. I use a simple flashlight (or lighthouse) analogy, explaining that the driven element where we launch or extract the signal is like the light bulb. The Yagi director acts like a lens to focus the signal, while the reflector acts like a mirror to reflect forward the energy that goes toward it.

Jay Thompson, W6JAY, winner of the Newsline Young Ham of the Year and ARRL Hiram Percy Maxim Awards, instructs a Scout about RDF at the Long Beach Scout-O-Rama. (Photo by Joe, KØOV)

With several transmitters active in a small park, QRM can be a problem. A spur 40 dB down on another fox frequency will be loud and clear when you are close to it. Therefore, your foxes should be as "clean" as possible, even though they are QRP. When you and the Scout find one, have him or her move 20 feet away from it before trying to get a bearing on the next fox's frequency, to minimize desense effects.

The 2-meter band is the obvious choice for beginning foxhunts because there is so much equipment readily available. Gain antennas for 2 meters are of a reasonable size and weight. Signal reflections aren't much of a problem in a park setting. Another option is the 70-cm band, where antennas dimensions are one-third that of 2 meters, but multipath is more evident.

Scouting events are just one possibility for foxhunting fun with youth. I have put on impromptu transmitter hunts for our church's youth group and at a community band picnic. At such outdoor events parents are grateful to have activities that get their kids out of their hair for a while and dissipate some of their youthful energy, so seize the opportunity.

Hunting Foxes in the Classroom

Winnie Hennigan, KA6OFZ, teaches ham radio topics to her fourth grade students in Santa Barbara, California as part of the Gifted and Talented Education (GATE) program. With help from her OM Jay, WB6RDV, her students have just learned to track radio transmitters.

Jay's first task was to teach the kids to properly point and turn a 2-meter Yagi antenna to get bearings. "I lined up four students side by side with their hands behind their backs," Jay told me. "Then I put a miniature transmitter in one of the students' hands. The student with the RDF set, standing a few feet in front of them, was asked to turn the antenna and determine which of the four was holding the transmitter."

Then it was time to go outside and find the three miniature transmitters. Jay sent out four students in each hunter group, and instructed them to share an RDF set among them. Each time the fox came on, a different member of the group was to be the lead hunter, holding the RDF set as the others helped.

Is it in the tree? This Scout is using my 2-meter on-foot RDF set, which has a handle at the exact balance point to avoid wrist fatigue. Helping him is Tom Gaccione, WB2LRH. (Photo by KØOV)

Frank Shannon, KR6AL, helps Carol Blake, KF6LQQ, an adult Handi-Ham Radio Camp attendee, learn the basics of VHF RDF. (Photo by Pat Tice, WAØTDA)

A different set of challenges confronted Marvin Johnston, KE6HTS; Frank Shannon, KR6AL; and Dennis Schwendtner, WB6OBB, as they brought foxhunting to students at Radio Camp at Malibu, California in early March. This annual event at Camp Joan Mier, sponsored by the Courage Handi-Ham System[2] of Minnesota, brings together persons of all ages and varying degrees of disability. Campers without ham licenses get help in studying for their tests. Those with their tickets try out adaptive equipment and learn new operating activities.

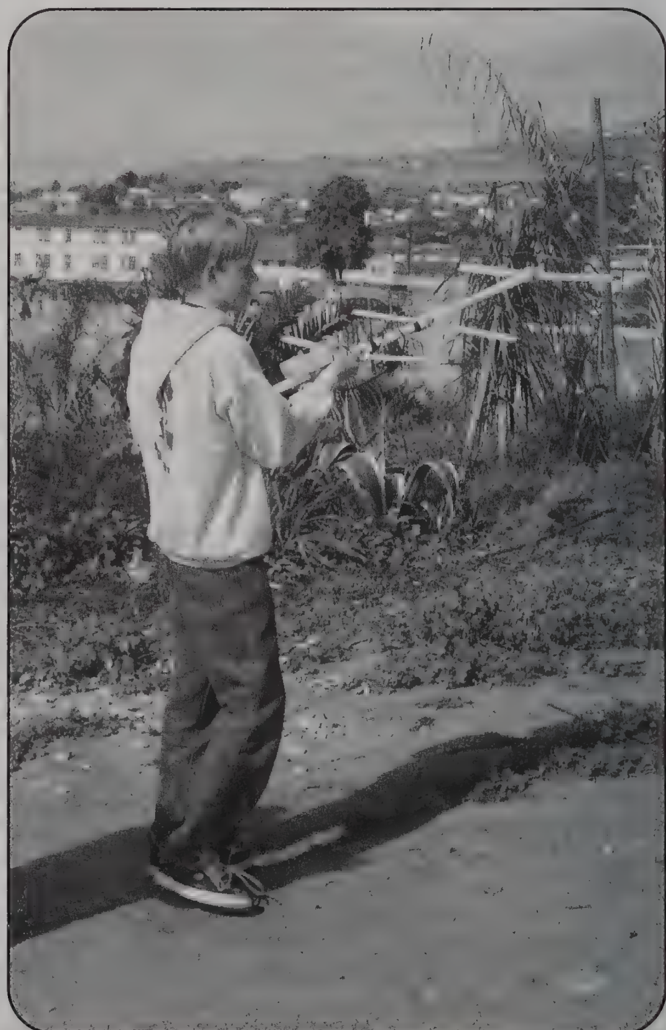
Many of the campers are visually impaired, but RDF sets with tone-pitch signal-strength indicators make it easy for them to get bearings and navigate to the radio foxes. "To help them in the last few feet, we put audible beepers on them," Marvin explains. "They could then get right up and touch them. Our biggest problem was that the grass made it tricky for some of the campers in wheelchairs."

Ham radio doesn't have to be part of the formal curriculum for students to enjoy RDF and learn from it. The proof is at Palos Verdes High School (PVHS) near Los Angeles. Dan Welch, W6DFW, a regular mobile "T-hunter," is using ham radio and transmitter hunting to train future engineers and scientists there.

Twenty years ago W6DFW and I worked for the same aerospace company. Now he is an independent contractor for a variety of electronic enterprises. Each of us got our start toward an engineering career from an early interest in radio.

"As a little kid, I was bugging all the hams in the area," Dan recalls. "If I saw an antenna, I knocked on the door. I met some interesting people, including Don Wallace, W6AM, at his old home by the Virginia Country Club in Long Beach. By fifth grade I was puttering with electronics. I built a number of radios with #30 vacuum tubes. I used to hang out at a local ham's place, chatting on CW and AM."

Dan didn't get his own ham license until long after he grew up, but he made up for lost time by guiding almost every member of his family into the hobby, including his son and grandson (see photo). He has also helped many other young people enter the world of science and technology. He started by becoming a volunteer at the California Academy of Mathematics And



Andy Bradford, one of the Road Warriors, gets a bearing atop a hill at Angel's Gate Park. (Photo by KØOV)

This Fox Talks

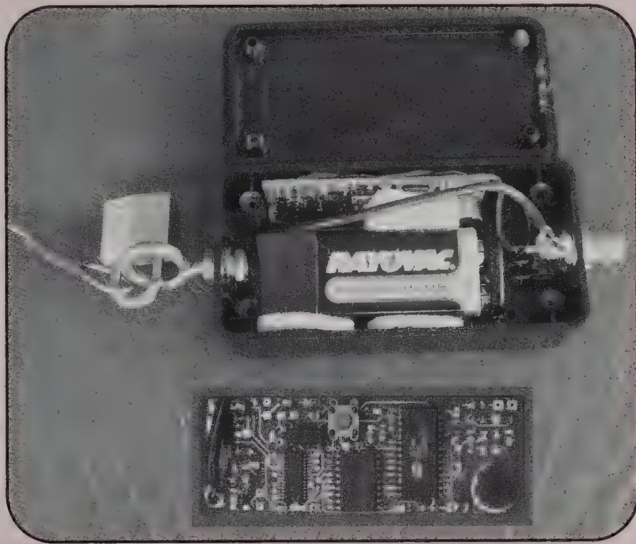
I am often asked what to use for transmitters at foxhunts in small parks and schoolyards. The possibilities are many. A page on my website (http://www.homingin.com) describes ways to adapt your handie-talkie or other low-power transmitter for the purpose. See my "Homing In" column in the Summer 2004 issue of *CQ VHF* for ammunition-can foxbox ideas.

For those who want to buy small, ready-to-go foxes, I suggest the new SquawkBox by Bob Simmons, WB6EYV. On one small circuit board, Bob has packaged a 50-milliwatt 2-meter transmitter, a voice record/playback chip with microphone, and a PIC microcontroller to time the transmissions. Just press the button, record your "Come find me!" message, and the SquawkBox will repeat it at one of 16 time intervals. Select from 15-second to 30-minute transmission spacing with four solderable straps.

The standard SquawkBox frequency is 146.565 MHz, used for hidden transmitter hunts in many cities around the country. Changing the crystal or the program jumpers on the ICS525-02 synthesizer will move the output frequency, but care must be taken to maintain purity in the output. The 146.565 unit that I checked on a spectrum analyzer easily met FCC limits for spurs and harmonics.

A standard 9-volt battery will power a SquawkBox for several hours, even with very short spacing between transmissions. Board and battery fit nicely in a 4" × 2" × 1 1/8" plastic box, as shown in the photo. It would also be easy to camouflage the board inside a . . . well, I'll keep my ideas secret for now. Let's see what you think up.

To demonstrate and practice international-style radio-orienteering (ARDF) with "MOx" CW messages and IARU-rules timing, Bob has designed a similar board called MicroHunt. It has a Morse generator program in the PIC to replace the voice chip. See Bob's website (http://www.silcom.com/~pelican2/SQUAWK_BOX.htm) for more on both units. *—Joe, KØOV*



It's easy to make drop-and-run hidden transmitters with WB6EYV's SquawkBox. The circuit board (inset) is only 2 1/2" × 1". I secure this mini-fox with piano wire and a small padlock to prevent theft.

With a little help, these Handi-Ham Radio Campers found the transmitter in the traffic cone. Left to right are Frank Shannon, KR6AL; Bryan Gorman, KB3KUQ; Jared Hunter, KG6WBR; and Helen Karnes, KF6JOV. (Photo by Pat, WAØTDA)

Science (CAMS).[3] It's a four-year magnet high school with a mission to increase the USA's pool of graduates in those disciplines.

"One of the things they do at CAMS is match students with adults having expertise in their areas of interest," says W6DFW. "I ended up mentoring four kids at one time. I worked closely with a science instructor, Graham Robertson, until he had to leave. They had a restriction on the number of years that anyone could teach there before being cycled out to another school."

Graham is now at PVHS, where students are learning radio and electronics as part of a 21st-century challenge. W6DFW is very involved, as I learned from him at a PVHS display during the WESCON electronics trade show.

This Car Drives Itself

In 2003 the federal Defense Advanced Research Projects Agency (DARPA) issued a challenge to industry and academia: Create an autonomous vehicle that can navigate from Point A to Point B with no human in control. The first entity to complete the DARPA Grand Challenge would win a million dollars. Expecting only a few proposals from large aerospace

firms and top universities, the sponsors were amazed to receive 106 applications. One of them was from PVHS.

Graham Robertson is primary instructor of the special class of gifted tenth, eleventh, and twelfth graders who are determined to win the purse. Calling themselves the Road Warriors, they tore into a donated Honda Acura and added sensors, actuators, and Linux computer equipment, ending up with the Doom Buggy. It reached the finals and participated in the 2004 official 200-mile race from Barstow, California to Primm, Nevada. No vehicle made it all the way.

The second DARPA Grand Challenge race will take place on October 8, 2005, this time with a $2,000,000 prize. The Road Warriors are redesigning the Doom Buggy to do better, but they are now up against 194 other teams. In addition to some parents with background in science and engineering, Graham has brought in experts to help the class, including a systems design consultant. W6DFW was tapped to teach basic electronics.

"I am the official instructor for this part of the class," says Dan. "I give lectures and homework. We meet five times every two weeks. First I covered AC-DC theory. We got into transistors a little bit and now we're doing some RF concepts. RDF fits into that category, but they aren't using it for the project because they aren't allowed to have any transmitters or receivers on the vehicle except for the emergency stop system. They can't even have any real-time telemetry or video coming back to them during the race."

Dan asked me to put on a weekend transmitter hunt just for the Road Warriors and I jumped at the chance. He said to expect as many as 25 students. Dividing them into teams of two would require about a dozen RDF sets. I didn't have nearly that many, so I called Mark Hayden, KF6DSA, an electronics instructor in the Community Education Center of Pasadena City College (PCC).

In 2001, KF6DSA taught a special multi-weekend class on RDF to seventh and eighth graders as part of the NASA Pre-college Science Academy (PSA). Besides learning all about transmitters, receivers, propagation, and signal tracking, each student built his or her own tape-measure Yagi and offset attenuator from parts kitted by Mark's assistant, Phil Barnes-Roberts, WA6DZS.

Phil used the attenuator circuit at my "Homing In" website (http://www.homingin.com>. He modified the layout to fit in a larger plastic box, making construction easier. "For safety and consistency, we drilled the attenuator cases before the students got them," says Mark. "We also pre-cut the perfboard and drilled holes for potentiometers and BNC connectors. Everything else was done by the students. They

Non-students participating in the Road Warrior class foxhunt were Dan Welch's son Mike, KG6FWH, and grandson Daniel, KG6WAP, who earned his ticket at age 7 last year. (Photo by KØOV)

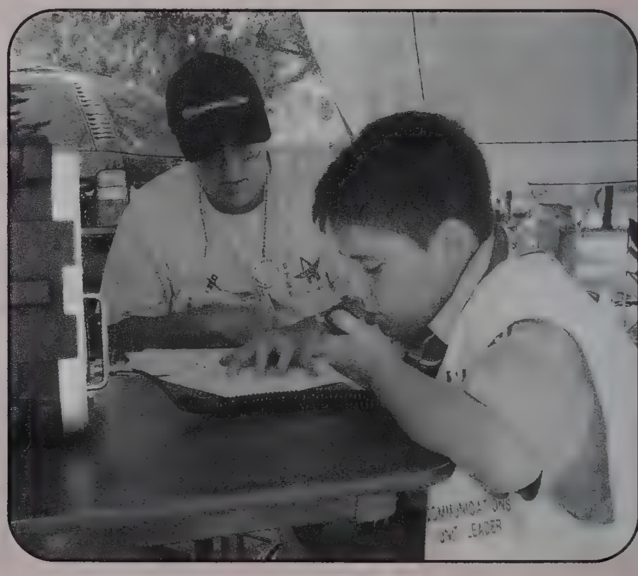
Show Off Emergency Comms, Too

In addition to transmitter hunting and on-the-air QSOs, the annual Long Beach Scout-O-Rama dramatically introduces young people and their parents to amateur radio's potential for disaster communications. Scouts are invited to send simulated emergency messages from stations set up by the Hospital Disaster Support Communications System (www.hdscs.org), an ARES group dedicated to helping 34 medical facilities in Orange County when their phones fail or become overloaded.

When a Scout arrives to participate, he or she is assigned to one of the HDSCS communicators at the simulated hospital Command Post. In our scenario, the hospital has suffered earthquake damage and regular communications are down. HDSCS members at their home stations are playing the parts of Red Cross, county Emergency Medical Services (EMS), and other hospitals. The Scout at the mock Command Post makes an amateur radio call to the appropriate entity and sends the message. Subjects include blood requests, patient transfer coordination, and status reports to EMS.

"Scouts are excited to try emergency radio operations and take it very seriously," says April Moell, WA6OPS, who leads HDSCS and organizes this part of the display. "They learn about message priority as well as the jargon of hospitals and amateur radio. They also find that it takes a little effort to coordinate talking and using the mic button. Last year one boy came back twice to ask if he could send another message." (He could.)

Joe Moell, KØOV
Assistant Coordinator, HDSCS



Wearing an HDSCS communicator's vest, a Scout sends a simulated emergency message on 2 meters under the guidance of HDSCS member Dennis Kidder, WA6NIA. (Photo by KØOV)

built the antennas completely by themselves, including cutting the PVC pipe and the tape measures."

PCC retained the antennas, attenuators, and scanner receivers when the class ended, so I was able to borrow them for the Road Warrior hunt. Between work on their autonomous vehicle and the rainiest Los Angeles winter in over a century, it was difficult to schedule a date. We finally had an opening in February. The site was Angel's Gate Park, the same location as the ARRL Southwestern Division convention hunts in 1995, 1999, and 2003.[4]

I scattered nine foxboxes throughout the 130 acres. I did not expect anyone to find them all, but having a large number helped spread out the students. They went out in pairs, with one RDF setup per pair. Each team was given a list of frequencies with the foxes in a different order, so they were less likely to be hunting for the same fox at the same time.

Two teams did the best, finding five transmitters in the allotted 90 minutes. Considering that international champion foxhunters take about an hour to find five required foxes in a forest, that's very good. "They found it interesting and challenging," Dan reported later. "One of them remarked, 'I learned that a chain-link fence can make a mighty long antenna!'"

"I would love to see some of these kids get into ham radio," Dan continued. "I think some of them will. I decide where to go with the electronics lessons, so in the coming weeks I will introduce the hobby, bring in a rig, throw up an antenna, and let them try it. I'm sure some will jump on it."

The Road Warriors have completed the required video demonstration of their 2005 DARPA challenge vehicle. If it passes review, DARPA officials will be visiting PVHS and the other candidates about the time this magazine reaches your mailbox. After the visits the agency will select 40 semi-finalists. The 20 finalists will be selected after a qualification event at California Speedway in late September. Watch newspapers and the DARPA Challenge website[5] to see if the Road Warriors are among them.

Are you using hidden transmitter hunts to help develop the next generation of radio amateurs? If so, please let me know about it. Your foxhunting stories and photos are always welcome. Send postal or electronic mail to the addresses on the first page of this column.

73, Joe, KØOV

Notes

1. See "A Foxhunting Jamboree," an article at the "Homing In" website, <www.homingin.com>.
2. <www.handiham.org>
3. <http://www.cams.csudh.edu/>
4. See "Homing In: Win Foxhunting Prizes, Mobile or On Foot" in the Winter 2005 issue of *CQ VHF*.
5. <http://www.darpa.mil/grandchallenge/>

Register Now for the 2005 USA Foxhunting Championships

Radio foxhunters of any age and at any skill level are invited to compete at the fifth annual USA Championships of Amateur Radio Direction Finding (ARDF), August 1 to 6, 2005. This year's national championships are being combined with the Third IARU Region 2 (North and South America) ARDF Championships and are being hosted by the Albuquerque Amateur Radio Club (AARC).

Besides separate on-foot direction finding competitions on the 2-meter and 80-meter bands, there will be opening ceremonies, practice sessions, a sightseeing day, and a closing banquet with awards presentations. The event center will be on the campus of the University of New Mexico, where competitors will be housed. Bus transportation to the competition sites will be provided. Entry fees will cover the competitions (including transportation to and from the sites), housing, and meals.

Although most participants will be licensed hams, the championship courses are open to anyone of any age, with or without a ham ticket. Here is your chance to learn from the best. Visiting radio-orienteers from outside the USA and IARU Region 2 (North and South America) are expected. Competitors will be divided into five age categories for males and four for females, with medals for top finishers in each category. Stateside winners will also be considered for positions on ARDF Team USA to the 2006 World Championships in Bulgaria.

AARC's official website for the 2005 USA and IARU R2 championships, <www.ardf.us>, is now online with a downloadable registration form as well as details about housing, rules, frequencies, and the climate of central New Mexico. To get an idea what it's like to participate in the USA Championships, see my "Homing In" column in Summer 2004 *CQ VHF* and a first-person article by Sam Vigil, WA6NGH, entitled "The US 2004 ARDF Championships: A Beginner's Adventures" in the November 2004 issue of *CQ* magazine.

Joe Moell, KØOV
ARRL ARDF Coordinator

By John Champa,* K8OCL

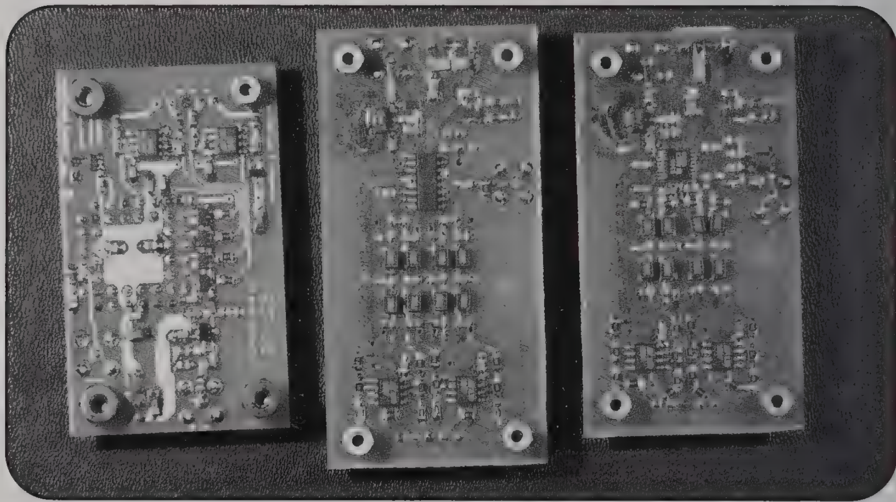
Communicating Voice, Video, and Data with Amateur Radio

The Hinternet on UHF

Digital Video Coming to the 440-MHz Band

In our previous column we wrote about the use of typical HSMM (high-speed multimedia) gear (IEEE 802.11 modulation operated under Part 97 regulations and power limits) in helping to deal with last year's tsunami and other natural disasters. We listed the elements of a survival kit recommended by Oklahoma Baptist hams. An old high school classmate, Thomas Barnes, reviewed the list and recommended some additions. Tom is a military historian and a Vietnam veteran who was with the First Infantry Division—"The Big Red One"—so we thought we should pass along these additions:

1. Duct tape. It makes a great way to seal long pants over boots to keep out mosquitoes, not to mention its value for the temporary repair of nearly everything else. One roll can be shared, so not everyone needs to take a roll.
2. Scissors. Take a good pair made of stainless steel, which will not rust in a wet tropical climate.
3. Personal sewing kit.
4. Repair kit for eyeglasses.
5. Maglite® brand flashlight. This is the type that will continue to work even if it is run over by a tractor/trailer.
6. A lot of batteries for the flashlight. If not used, they can be bartered.
7. An emergency supply of toilet tissue.



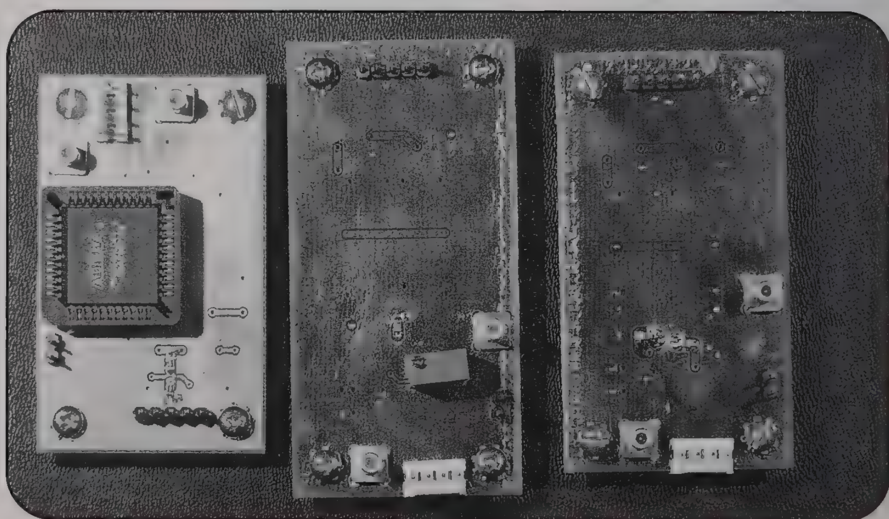
Bottom view of the Orthogonal Frequency Division Multiplexing (OFDM) modem. (Photos courtesy of John, KD6OZH)

HSMM Testing

Until now all of our discussions regarding HSMM radio within amateur radio have been about the use of inexpensive COTS (commercial-off-the-shelf gear) used for RLANs (radio-based local area networks). This gear is one of the IEEE 802.11 standard radios with the addition of an outside antenna and perhaps a BDA (bi-directional amplifier, usually in the 1.8-watt range made especially for HSMM by the FAB Corporation (http://www.fab-corp.com/).

Some linked HSMM radio repeaters now cover an entire community. However, what is clearly needed for amateur radio's national high-speed digital network ("The Hinternet") to continue to grow are other methods of getting better range than the 2.4-GHz ham band normally allows. How do we do that and still get the high-speed data rates we need?

During one of the periodic teleconferences held by the ARRL HSMM Working Group it was decided to form several RMAN (Radio Metro Area Network) project teams within the



Top view of the OFDM modem.

*Chairman of the ARRL Technology Task Force on High Speed Multimedia (HSMM) Radio Networking; Moon Wolf Spring, 2491 Itsell Road, Howell, MI 48843-6458
e-mail: <k8ocl@arrl.net>

Working Group to answer this question. Two of these teams have made great progress: the RMAN-VPN Team, which will be featured in our next column, and the RMAN-UHF Team, which uses the lower ham bands, such as 440 MHz, for much longer range network links.

The Working Group's RMAN-UHF Team project leader is John Stephensen, KD6OZH. John has developed a modem designed to use OFDM (Orthogonal Frequency Division Multiplexing) modulation, which can be used with conventional ham gear (amplifiers and antennas) in the 440-MHz ham band. Technical details regarding the OFDM modem design can be found in the March/April 2005 issue of *QEX* (pp. 26–35) and at <http://www.arrl.org/ hsmm/>. The alpha test equipment photos of the OFDM modem included with this article were provided by John.

OFDM modem testing is expected to begin this summer at four locations in the United States:

• Livingston County, MI—HSMM Experimenters team leader Jon Harris, KC8WAZ (jonharris2@comcast.net)

• Emmaus, PA—HSMM Experimenters team leader Carl Stevenson, WK3C (wk3c@wk3c.com)

• College Station, TX—Hinternet infrastructure specialist Gerry Creager, N5JXS (N5JXS@arrl.net)

• Fresno, CA—RMAN-UHF Team project leader John Stephensen, KD6OZH (KD6OZH@verizon.net).

What does all of this have to do with digital video on the 440-MHz band? The OFDM modem is expected to be able to operate at a maximum data rate of 2.4 megabits per second (M/bps). Initially, we will be doing link quality testing. Later, to push the outside of this envelope for the tests, the open-source ITU-T standard software video and audio CODEC (coder-decoder) of H.323 will be used. This should produce excellent full-color and full-motion video for some wonderful two-way high-speed digital QSOs with outstanding audio quality, too. In addition, the OFDM modulation will only occupy 2 MHz of a local ATV channel. This compares favorably with the present 6 MHz used by analog ATV, so the spectrum efficiency is much better. We have designated this test mode as ADV (Amateur Digital Video) to distinguish it from DATV (digital ATV), which is mostly an image mode based on MPEG CODECs used by European ATV experimenters.

73, John, K8OCL

By Gary Pearce,* KN4AQ

FM/Repeaters—Inside Amateur Radio's "Utility" Mode

The Simplex Test

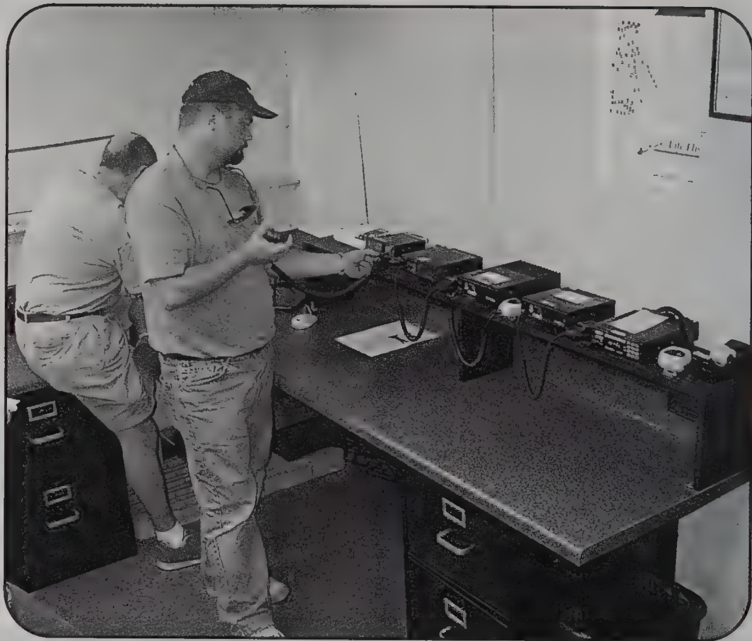
Last fall a couple of local ARES ECs (Emergency Coordinators) pulled a trick on their members during the annual ARRL SET (Simulated Emergency Test). They yanked the plug on all the primary and backup ARES repeaters and let the members scramble as best they could to recover and get some communicating done on simplex. The result was pretty interesting. There was less chaos than I might have predicted, but still plenty of on-the-job learning. Few hams in my area are dedicated to simplex. Some occasionally use it, but most hams here rely heavily on repeaters. How is it in your area?

Only a few key people had advance knowledge of the scenario developed by Wake County, North Carolina EC Tom Brown, N4TAB, and Durham County EC John LeMay, KB4WGA. I wasn't one of them. The scenario included tornados, flooding, EOC evacuations, multiple repeater failures, and simplex operation. Tom had announced in advance that the exercise would rely on simplex and cross-band repeating, but didn't add any details. Wake and Durham counties are adjacent to one another, with Durham lying northwest of Wake. The cities of Raleigh and Durham and suburbs form one large metropolitan area about 40 miles in diameter. An emergency that affects one town will likely affect the other, or at least bring ARES volunteers out for mutual aid.

I tuned into the primary wide-area ARES/SKYWARN repeater on 146.88 MHz. This is a wide-coverage machine 1400 feet up a TV tower, and it provides about a 60-mile radius of coverage for mobiles across terrain that is fairly flat. I switched on my radio at the scheduled 9 AM start time to find the operation already under way, with KB4WGA reporting a tornado touchdown in Durham County.

I didn't have an official part to play in the test, so I decided to act as a scribe, to monitor and take notes on everything I could hear, and not to intercede in the actual operation. I live near the border between the two counties, and with a 17-foot dual-band vertical just above the roof of a two-story house, I'm in a fairly good position to hear simplex stations throughout both counties. I could have jumped in and provided good relay capability, and modesty does not prevent me from saying that I've done a ton of that kind of thing in the past—enough, I thought, such that I didn't need any more practice. However, many new hams in the area did need the experience. There were other leaders who could give them guidance. I thought the best contribution I could make was to just listen and transcribe the operation as I heard it, so we could take it apart later and learn what worked and what didn't.

It turns out that this taxed my *station,* which can monitor two HF and five VHF or UHF frequencies at once (more if you count HTs), and my *ears,* which can't monitor five frequencies at once if they're all active. In this test sometimes they were. Thus, I missed a few things, but I think I caught the essence of the test.



Durham County, North Carolina Emergency Coordinator John LeMay, KB4WGA (right), operates the radio during the annual ARRL Simulated Emergency Test. Assisting in the test, and behind John, is David Snyder, W4SAR. (Photos by KN4AQ)

I'll give you the play-by-play. Callsigns have not been changed to protect the innocent. I think we learn as much as or more from the things that go wrong as we do from the things that go right, and I'll include both. I have nothing but praise for everyone's participation. *Thank you* to the local hams, and all hams everywhere who participate in drills and real activations, for taking time to join this activity!

The Play-by-Play

After announcing the start of the drill with the tornado touchdown at 8:58 AM on 146.88, KB4WGA moved to Durham's local 145.45 repeater and began an ARES net. Virginia Enzor, NC4VA, started a SKYWARN net on 88. Then I logged my first critical comment. *Minutes* had gone by with a lot of dire

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weather warnings and nary a "this is just a drill" to be heard since the initial broadcast. Denyse Walter, K4DAW, later reported that she was running errands with her mother and just tuned in for a few minutes. Her mom was very concerned about all the tornados, and in the time they were listening no one said "drill." Finally, N4TAB said it. Meanwhile, the check-ins started rolling in on the Durham 45 machine. N4TAB appeared there to see if they needed Wake ARES assistance.

9:06—KB4WGA asks if there were any Durham AECs (assistant ECs) who could begin the telephone-call tree. Jerry Gualt, KI4CCB, says he can do it. Later he reports that no other AECs were available, and that on the general call-up he got some answers, a few wrong numbers, and lots of recordings, but no volunteers. (Great, though, to have a bunch of new "KI4" hams involved. Many of you just eat up this kind of activity!)

9:07—KB4WGA reports a tornado touchdown at a school near the Wake County line. He asks for a SKYWARN liaison, and Sterling Damron, KD4KVG, volunteers from Fayetteville. Sterling is an enthusiastic SKYWARN volunteer, but Fayetteville is 65 miles from the local-coverage Durham repeater and his signal is weak. A shallow fade will take him out completely, so he might not have been the best choice as liaison, but he holds up okay while relaying information back and forth to the 88 SKYWARN operation. I guess you go to SET with the army you have, too.

9:11—KB4WGA asks for volunteers to go to the school hit by the tornado. At first there's no response. Finally. someone volunteers and heads out. On 88 Bob Woodson, WX4MMM, reports a funnel cloud in north Wake County.

9:13—On 88 N4TAB asks if anyone can travel to the Wake County EOC, which is being activated. Bob Conder, K4RLC, and Liz Stanley, KF4UQZ, respond. K4RLC is dispatched.

9:18—Wayne Blackwell, KD4SLQ, appears on the Wake County ARES primary repeater on 145.39 asking if Wake ARES is active. Ronnie Reams, WA4MJF, who has even more radios than I do and is always monitoring everywhere, replies that Wake ARES is on 146.88. What Ronnie missed was that the 88 repeater had just gone down. Later we learn that control operator Danny Hampton, K4ITL, turned off 88 as part of the exercise.

There is some confusion about the role of the 39 machine. It's supposed to be the primary county ARES repeater and the backup SKYWARN repeater. However, few hams look to it first for ARES; everyone flocks to the big 88 machine. Wayne gets a gold star for showing up there quickly. There's no way for me to tell how many of the ARES hams on 88 have missed the cue or don't know to switch to 39, since there's no roll call. At this point, Wake ARES hasn't been officially activated anyway, but SKYWARN should be on the move.

9:19—KB4WGA asks for a volunteer to take over NCS on the Durham 45 repeater. A station offers, but says he isn't familiar with this net's protocols. John accepts him anyway and says, "Just take check-ins." KI4CCD reports no response from any AECs on the call tree. Another ham volunteers to help with the "all-members" telephone call-up. They split the list and go to work.

9:24—So far no one within range of my station has used 146.88 simplex to announce the move to 145.39 for those who either don't know to move or don't realize the repeater is down. This area does not have a tradition of operating simplex on failed repeater output channels. In other areas that is standard procedure.

9:25—On 39 N4TAB announces that Wake ARES is mobilizing to support Durham ARES and is moving to the secondary backup 147.195 machine to leave 145.39 clear for SKYWARN, which has been receiving simulated storm and damage reports. A few stations begin to appear on 195, while NC4VA moves the SKYWARN net to 39.

9:27—One of the Durham call-tree volunteers has been confused about which list he's supposed to be using. KB4WGA gets him on the right track.

9:28—N4TAB informs Durham ARES that 88 is down, and ARES/SKYWARN activity is split between 39 and 195. Wake County ARES AEC Mark Gibson, N4MQU, begins taking ARES check-ins on 195.

9:33—KB4WGA asks for a Durham volunteer to travel to a Rougemont command post about 15 miles north of the city. No takers.

9:37—N4TAB asks N4MQU if he can re-deploy to the Wake County EOC in downtown Raleigh. Mark says he can, and Liz, KF4UQZ, picks up net control on 195.

9:38—Ronnie, WA4MJF, talks to N4TAB on the #3 Wake County ARES backup machine, 146.64, informing him that he can't operate on 147.195. Ronnie is running a commercial radio that doesn't have that frequency programmed. As Tom is trying to tell Ronnie to remain on 64, I turn the 64 repeater off in an unscripted move. Tom calls me on the phone and applauds.

9:43—The 145.39 repeater goes off the air, courtesy of K4ITL. KB4WGA announces on 45 that the Durham EOC has been destroyed by a tornado, and communications is being relocated using the new DFMA (Durham FM Association) MCU (mobile communications unit).

9:44—The 147.195 repeater goes down, also courtesy of K4ITL. Wake County is in radio silence, with 88, 39, 64, and 195 all off the air. KF4UQZ calls for any stations on 195 simplex. On 88 simplex Frank Bridges, AE4MY, announces that Wake ARES is moving to 146.52 simplex. A few operators begin to appear there. KF4UQZ announces on 195 simplex that operators should go to the 146.64 backup and is told that 64 is also down, so move to 52 simplex. Note that there is no listed Wake County ARES simplex channel (this was fixed as a result of the SET).

9:53—More stations appear on 52 amid some doubling and confusion, as not all stations can hear one another. There is no net control yet. Vaden Holmes, N4DIL, appears with a big signal on 52 from south Raleigh and relays some traffic between N4MQU and N4TAB. Vaden has an 80-foot tower with his antenna on top and becomes the de facto net control.

9:59—NC4VA has moved the SKYWARN net to the KD4RAA/K4JDR linked UHF system, where it remains until the end of the exercise. With six repeaters linked full time, this network provides excellent coverage of the area. However, UHF is pretty much out of the way around here, and few stations appear on the net.

A station whose innocence I *will* protect calls me on the phone to ask for help unlocking his radio, which he somehow accidentally locked so none of the front-panel buttons work. That sends me scrambling through manuals until I find the cryptic key sequence that does the job. I'll also protect the name of the manufacturer, since all suffer from this menu overload to one degree or another.

10:01—KB4WGA announces that the 145.45 repeater has failed and Durham ARES is moving to 146.52. John an-

Tom Brown, N4TAB, Wake County, North Carolina EC.

nounces this on the 45 repeater, which is actually still working and is never really turned off. The Wake repeaters were actually turned off for a short time, which risks their unavailability for an actual emergency, but simulates the problem of repeater failure more accurately.

10:04—N4TAB notes that N4DIL has the best 52 simplex signal in Wake County. Vaden says this is his first ARES activity, so he's not all that sure what he needs to do. Meanwhile, here he is in the spotlight as the one station everyone can hear, and he relays messages between stations who are out of simplex range of one another.

Come to think of it, there are precious few strong simplex signals appearing. Later, many operators will note that they do not have effective simplex base stations. I suspect antenna restrictions are a key factor. I'm able to hear some of the Durham simplex stations appearing on 52. The channel is becoming busy and I hear a fair number of collisions.

N4TAB asks Wake AEC David Crawford, KF4VXJ, to relay a message to K4RLC to meet him on 40 meters, 7210 kHz. David does, and replies that Bob lost his 40 meter antenna and will need to meet Tom on 80 meters, 3927 kHz. I tune my HF rig, adding yet another speaker to the mix. Tom and Bob hook up with good signals on HF. Tom is heading to the North Carolina Emergency Management Central Branch EOC in Butner.

I'll pause here to note that many other Wake, Durham, and surrounding county repeaters are still working. We're pretty much ignoring them, as the edict was to move to simplex. However, would operators know how to find them, set their tones, and operate through them if needed? This lack of repeater flexibility has been an ongoing problem for local hams, but one this exercise would not test.

10:07—N4TAB announces that the Wake County EOC in downtown Raleigh is flooded and is being evacuated to the Wake County Commons complex on Poole Road. This is southeast of town, in the opposite direction of Durham County, and will shortly present a communications problem.

10:10—KB4WGA arrives at the temporary Durham EOC at Durham County Stadium and starts setting up the DFMA MCU. He announces that the Durham simplex net will move to 146.535 to avoid the conflict with Wake County on 52. N4DIL relays the move to Wake ARES stations. N4MQU asks N4DIL if he could use some help and heads to DIL's home.

At this point, I still have no idea how many operators are out in the cold, having lost their connection through area repeaters and either don't have enough antenna to participate on simplex or just don't know what frequency to tune. A few stations are checking in on simplex, maybe more of them in Durham than in Wake. A station in Hillsborough, west of Durham County, comes up on the still-working 145.45 repeater and asks where the activity went. He's told "535" and asks, "Where's that?" He's told it's 146.535 simplex. He switches over, but is able to hear few stations from that distance.

10:17—KB4WGA is having trouble with intermod from a powerful paging transmitter on a Durham hospital just down the street from his staging area. He's having intermittent trouble hearing some stations on simplex, either 52 or 535.

10:21—WA4MJF and his wife Sherry, KB4EXL, take their personally financed and built mobile com unit to Wake County Commons to set up emergency communications. KF4VXJ is dispatched to help. Vaden, N4DIL, who has been handling all the relaying on 52, is fried, and asks Liz, KF4UQZ, to take over as net control in Wake. Liz picks it up, but doesn't have nearly the coverage Vaden did.

10:22—K4ITL turns the 88, 39, and 195 repeaters back on, and I turn 64 back on at about 10:30. No one notices for a long time, and when some stations appear and ask where the activity is, they are directed to simplex. No one thinks to pull the operation back to the repeaters. This is not surprising; most operators are assuming the repeaters are still "off for the drill." However, that had not been specified as part of the operation. In real activations in the past, I've seen repeaters go down, operation shift to less desirable facilities, and not move back because no one was checking to see if the main repeater was back up. The lesson: Check the repeaters now and then!

10:24—KB4WGA has the Durham MCU up and running. He's still getting intermod, but is in contact with his field stations.

10:31—Durham MCU tries to reach *any* Wake ARES official on 52. No answer. Lowell Tieszen, KK4PH, in Durham tries to relay with a better signal into Wake County, but still no answer. Am I the only one hearing them? I decline to intervene, but I do slip down to 40 meters and cue N4TAB to listen to this failure. Liz, KF4UQZ, hears me and spills the beans on 52. Now N4DIL is hearing KK4PH, but thought others were hearing them okay. He relays that KK4PH wants a test of Wake-Durham communications and tells Liz to switch to 535 and call Durham EOC.

This is a problem. Liz lives in southeastern Wake County. She has a nice home station, but can't reach the Durham MCU on simplex. Meanwhile, I notice another problem. 52 and 535 are only 15 kHz apart. That's not far enough to avoid adjacent chan-

nel interference, and I'm getting hit by N4DIL's strong signal while trying to listen to the Durham activity on 535. Later AE4MY would report he was having the same problem. The solution will be for simplex stations to avoid the "15 kHz splits," with Durham ARES picking another frequency. Wake ARES might find something better than 52, the National Simplex Frequency, as well.

10:45—N4MQU arrives at N4DIL's home and activates the station as NC4WC. He makes contact with the Durham MCU, amid some doubling with other stations trying to check in. Following Durham's request for a communications check, he tries to get KB4EXL at Wake Commons to contact the Durham MCU on 52, but I can hear that Durham has already switched back to 535. I keep silent.

10:53—Bob, K4RLC, is dispatched to Wake County Commons to assist. He gets lengthy directions on 52. Later a station will suggest that all the direction-giving should have been done on another frequency. A very good point. However, over the years I've seen that we do not have much coordination of simplex frequencies besides 52 (and don't really have a lock on that). Changing frequencies often sends one or both stations off to a black hole from which they sometimes never emerge.

10:56—KF4VXJ announces that the Wake County Commons MCU can't reach the Durham MCU on simplex. NC4WC says there's a lot of doubling and tripling on 52, and stations should go through net control. K4RLC is still getting directions to the Commons.

11:02—N4TAB calls NC4WC on 52 and announces that he's arrived in Butner. NC4WC asks him to call the Wake MCU. They can't make contact. NC4VA is still holding down the fort for SKYWARN on the UHF link system. WX4MMM and one or two other stations are all that check in.

11:07—NC4WC repeatedly calls for N4TAB on 52, but I can hear that Tom is on 535 talking to Durham MCU.

11:08—Mike Murphy, WA4BPJ, checks in on 52. NC4WC asks him to sweep for more check-ins. Mike does, but no replies. Too bad Mike wasn't around earlier. He has a great simplex station in North Raleigh and would have added a lot to coverage.

11:09—K4RLC gets final directions into Wake Commons, still on 52. Jose Guzman, KD4JWF, files a rare SKYWARN report on the UHF linked system.

11:26—Wake EC N4TAB announces the end of the exercise, and that there will be a critique on 146.88 at noon.

Critique

Most of the problems that I noted in the play-by-play were picked up by other stations in their net comments. My contribution to the net was that this exercise was all "fire-drill"—that is, it was all logistics on getting people on the right frequency or in the right location, or both. The hams carried no "client" traffic. What would they have done if Wake County Emergency Management had loaded them down with urgent messages for Durham County? Somehow, I expect, they would have adapted and gotten the traffic flowing. Meanwhile, all the churning they did was valuable. People were learning a lot in a short period of time. However, the real value of it will be measured in the changes they make now, and how they respond next time.

As N4TAB put it, "Next time we'll try to make a different set of mistakes."

Another Wake County ARES Test

Wake County ARES followed up in February with a smaller simplex test on their regular weekly net, just asking all stations to listen on the 146.88 repeater input to see and report how many stations each operator could hear. Once again, there were only a few stations with good simplex base stations, something I'd define as at least a ground-plane antenna mounted above the roof and a typical 45-watt radio. Many had indoor antennas, and some had only handheld radios with nothing better than the rubber duck. Several hams stated their intention to improve their simplex coverage. Again, though, antenna restrictions in many neighborhoods and for apartment-dwellers will make this difficult.

They also announced two simplex channels as primary and secondary simplex. The Wake ARES web page is <www.wakeares.org>.

The Need for Flexibility

How realistic is the need for good simplex coverage? Is it likely that all repeaters in one area will go down at once? No, it would be very rare. The only example I can think of was during Hurricane Andrew, which knocked down everything in south Florida, and if you were there, your simplex station would have been included. However, simplex

would have been the first VHF capability to be resurrected. I'm sure a few of you out there have some examples you can add to this.

I think the lesson is more about flexibility, being ready for a variety of circumstances. Riley Hollingsworth, K4ZDH, the FCC's top amateur radio rules enforcer, says that ham radio cannot be stopped. However, if one repeater tower going dark stops *you,* then you have some work to do, whether it's improving your station or just getting to know all the repeaters in your area a lot better.

APRS Voice Alert Works for N1RWY

In the Winter 2005 *CQ VHF* column I passed along an idea for on-the-road monitoring called APRS Voice Alert, initiated by Bob Bruninga, WB4APR, the "father" of APRS. The column drew a testimonial from Jason Baack, N1RWY, who wrote:

> I travel the east coast several times a year from Florida to Maine, and ham radio follows me along the way. In the past two years, driving between FL and ME I have had exactly two conversations on 146.52.
>
> On 144.390 (100 Hz tone) in "voice alert" mode I have had over three dozen conversations (moving to 146.52 or .58). This does not include the few dozen keyboard-to-keyboard (or key pad on the mic) text conversations I have had as well from folks seeing me on their APRS screens.
>
> As you said in your article, you do have four potential QSO guarantees while using the 'voice alert" system. Best of all, it is passive and it works.

A quick review: On the road, monitor the APRS packet frequency 144.39 with 100 Hz CTCSS decode turned on. If you have an APRS beacon in your vehicle, set it to encode/decode 100 Hz as it beacons, and turn up the volume so you can hear. In theory, any time you hear your speaker open with a burst of packet containing 100 Hz, it will be from another station ready and willing to have a voice contact with you. Call the station, using voice and 100 Hz on 144.39, and quickly move to a more appropriate simplex channel. You won't know his or her callsign unless you have a packet display running.

Echolink/IRLP and Tsunami Communications

December's tsunami disaster in the countries ringing the Indian Ocean brought out heroic communications efforts by hams. As it is here in America, much of the communications was handled on VHF/UHF FM. We don't get to hear that, of course, but Internet linking systems such as Echolink and IRLP are changing that equation.

I wasn't able to spend time listening to amateur radio, or my computer, in the immediate aftermath of the disaster. I'm glad to report that my freelance audio/video engineering business has taken a big upsurge, but it's reduced the time I have to play on the radio. Thus, I didn't hear the activity first hand they way I did when Echolink played the ham's role in recovering *Columbia* shuttle debris or during the spate of hurricanes that hit the southeast last summer. However, there are some accounts of the new capability on the web.

Tyson Schultz, N7ZMR, vacationed in the area this past March and logged this on his website (www.geocities.com/timbercutter/tsunami/index.html):

> When this first happened I remembered that there is a high-level Echolink node (http://www.echolink.org) in nearby Phuket. I logged my computer into that node and began listening to 145.550 MHz simplex. This had become the Royal Thai Coast Guard tactical frequency for operations for a number of reasons.
>
> The complexity of the disaster caused a total gridlock of the usual communication systems and the need for communications to be established between these remote areas and headquarters in Bangkok. Running on VHF and linked to the Internet proved to be the most reliable form available.
>
> With this system in place we were able to hear the rescue operations live from the scene, as the first helicopter arrived at Phi Phi island it was around 10 PM Thailand time, dark. With my wife sitting in to translate the conversation for me we could hear the helicopter pilot talking to people on the ground who were trying to guide the aircraft to the beach with their flashlights so he could land. The pilot surveyed the area with a spotlight and said he could not land anywhere safe because the debris and broken poles with wires attached would be too dangerous. You could hear how desperately the people wanted him to land, but all the pilot could do was circle and advise them on what needed to be done so he could land at a later time. He told them to remove some broken palm trees from the tennis court; that is where they would try to land when morning came. After circling for nearly an hour, the pilot reported to Bangkok HQ via Echolink (1000 miles to the north) that he had the metric equivalent of only 600 lbs. of fuel and had to return back to Phuket air base.

The armchair quarterbackers on eham and the qrz.com message boards questioned how Echolink could help in a disaster area, as theoretically all Internet service is wiped out. Details are often sketchy, and hams have been known to exaggerate both their capability and results in emergency communications. However, this VoIP communications system isn't designed to be the channel into the heart of a disaster area. It feeds the stations on the periphery, where there is power and Internet, but where radio channels are clogged. Hams have the organizational capability to move traffic, and the VoIP networks let them use radio where radio is most effective, and the Internet where that's the best choice. Another tool in the kit.

VoIP has the added advantage of letting us listen in from the rest of the world. Most of us won't be able to help, but you never know where a missing puzzle piece might come from.

KN4AQ Leaves FM Columnist Position

Sadly, for me anyway, this must be my last regular FM column in *CQ VHF.* The reason is simple—time. I freelance and produce my own projects in audio/video (or "multimedia," as they say today). I'm not the world's best time manager, and I have a couple of projects that are far behind schedule. Each column requires several hours that I must take from that work. Columns that require research—mostly telephone interviews or extensive e-mail—take even more time. Today I'm supposed to be training on a new video editing program I've installed, and then editing a program I've been shooting over the past year. I thought about telling Joe, N6CL, I was leaving without writing this quarter's column, but I just couldn't do it. I wrote the simplex test story for a local club newsletter and figured that with a simple rewrite it would be valuable and interesting for a wider audience. The rewrite took six hours (I'm not the fastest writer, either).

I think FM and repeaters deserve regular attention. I'm glad *CQ VHF* wanted to include this column, and I appreciate that N6CL asked me to do it. Some of us old timers in FM remember how the "traditional" hams tried to relegate us to second-class status in the early days—not "real" ham radio—until FM became the most popular mode. It may be the "utility mode" now, but there are still challenges ahead. I hope to contribute to them in the future.

73, Gary, KN4AQ

CQ's 6 Meter and Satellite WAZ Awards

(As of March 31, 2005)

By Floyd Gerald,* N5FG, CQ WAZ Award Manager

6 Meter Worked All Zones

No.	Callsign	Zones needed to have all 40 confirmed
1	N4CH	16,17,18,19,20,21,22,23,24,25,26,28,29,34,39
2	N4MM	17,18,19,21,22,23,24,26.28.29,34
3	JI1CQA	2,18,34,40
4	K5UR	2,16,17,18,19,21,22,23,24,26,27,28,29,34,39
5	EH7KW	1,2,6,18,19,23
6	K6EID	17,18,19,21,22,23,24,26,28,29,34,39
7	KØFF	16,17,18,19,20,21,22,23,24,26,27,28,29,34
8	JF1IRW	2,40
9	K2ZD	2,16,17,18,19,21,22,23,24,26, 28,29,34
10	W4VHF	2,16,17,18,19,21,22,23,24,25,26,28,29,34,39
11	GØLCS	1,2,3,6,7,12,18,19,22,23,25.28,30,31,32
12	JR2AUE	2,18,34,40
13	K2MUB	16,17,18,19,21,22,23,24,26,28,29,34
14	AE4RO	16,17,18,19,21,22,23,24,26,28,29,34,37
15	DL3DXX	1,10,18,19,23,31,32
16	W5OZI	2,16,17,18,19,20,21,22,23,24,26,28,34,39,40
17	WA6PEV	3,4,16,17,18,19,20,21,22,23,24,26,29,34,39
18	9A8A	1,2,3,6,7,10,12,18,19,23,31
19	9A3JI	1,2,3,4,6,7,10,12,18,19,23,26,29,31,32
20	SP5EWY	1,2,3,4,6,9,10,12,18,19,23,26,31,32
21	W8PAT	16,17,18,19,20,21,22,23,24,26,28,29,30,34,39
22	K4CKS	16,17,18,19,21,22,23,24,26,28,29,34,36,39
23	HB9RUZ	1,2,3,6,7,9,10,18,19,23,31,32
24	JA3IW	2,5,18,34,40
25	IK1GPG	1,2,3,6,10,12,18,19,23,32
26	W1AIM	16,17,18,19,20,21,22,23,24,26,28,29,30,34
27	K1LPS	16,17,18,19,21,22,23,24,26,27,28,29,30,34,37
28	W3NZL	17,18,19,21,22,23,24,26,27,28,29,34
29	K1AE	2,16,17,18,19,21,22,23,24,25,26,28,29,30,34,36
30	IW9CER	1,2,6,18,19,23,26,29,32
31	IT9IPQ	1,2,3,6,18,19,23,26,29,32
32	G4BWP	1,2,3,6,12,18,19,22,23,24,30,31,32
33	LZ2CC	1
34	K6MIO/KH6	16,17,18,19,23,26,34,35,37,40
35	K3KYR	17,18,19,21,22,23,24,25,26,28,29,30,34
36	YV1DIG	1,2,17,18,19,21,23,24,26,27,29,34,40
37	KØAZ	16,17,18,19,21,22,23,24,26,28,29,34,39
38	WB8XX	17,18,19,21,22,23,24,26,28,29,34,37,39
39	K1MS	2,17,18,19,21,22,23,24,25,26,28,29,30,34
40	ES2RJ	1,2,3,10,12,13,19,23,32,39
41	NW5E	17,18,19,21,22,23,24,26,27,28,29,30,34,37,39
42	ON4AOI	1,18,19,23,32
43	N3DB	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
44	K4ZOO	2,16,17,18,19,21,22,23,24,25,26,27,28,29,34
45	G3VOF	1,3,12,18,19,23,28,29,31,32
46	ES2WX	1,2,3,10,12,13,19,31,32,39
47	IW2CAM	1,2,3,6,9,10,12,18,19,22,23,27,28,29,32
48	OE4WHG	1,2,3,6,7,10,12,13,18,19,23,28,32,40
49	TI5KD	2,17,18,19,21,22,23,26,27,34,35,37,38,39
50	W9RPM	2,17,18,19,21,22,23,24,26,29,34,37
51	N8KOL	17,18,19,21,22,23,24,26,28,29,30,34,35,39
52	K2YOF	17,18,19,21,22,23,24,25,26,28,29,30,32,34
53	WA1ECF	17,18,19,21,23,24,25,26,27,28,29,30,34,36
54	W4TJ	17,18,19,21,22,23,24,25,26,27,28,29,34,39
55	JM1SZY	2,18,34,40
56	SM6FHZ	1,2,3,6,12,18,19,23,31,32
57	N6KK	15,16,17,18,19,20,21,22,23,24,34,35,37,38,40
58	NH7RO	1,2,17,18,19,21,22,23,28,34,35,37,38,39,40
59	OK1MP	1,2,3,10,13,18,19,23,28,32
60	W9JUV	2,17,18,19,21,22,23,24,26,28,29,30,34
61	K9AB	2,16,17,18,19,21,22,23,24,26,28,29,30,34
62	W2MPK	2,12,17,18,19,21,22,23,24,26,28,29,30,34,36
63	K3XA	17,18,19,21,22,23,24,25,26,27,28,29,30,34,36
64	KB4CRT	2,17,18,19,21,22,23,24,26,28,29,34,36,37,39
65	JH7IFR	2,5,9,10,18,23,34,36,38,40
66	KØSQ	16,17,18,19,20,21,22,23,24,26,28,29,34
67	W3TC	17,18,19,21,22,23,24,26,28,29,30,34
68	IKØPEA	1,2,3,6,7,10,18,19,22,23,26,28,29,31,32
69	W4UDH	16,17,18,19,21,22,23,24,26,27,28,29,30,34,39
70	VR2XMT	2,5,6,9,18,23,40

Satellite Worked All Zones

No.	Callsign	Issue date	Zones Needed to have all 40 confirmed
1	KL7GRF	8 Mar. 93	None
2	VE6LQ	31 Mar. 93	None
3	KD6PY	1 June 93	None
4	OH5LK	23 June 93	None
5	AA6PJ	21 July 93	None
6	K7HDK	9 Sept. 93	None
7	W1NU	13 Oct. 93	None
8	DC8TS	29 Oct. 93	None
9	DG2SBW	12 Jan. 94	None
10	N4SU	20 Jan. 94	None
11	PAØAND	17 Feb. 94	None
12	VE3NPC	16 Mar. 94	None
13	WB4MLE	31 Mar. 94	None
14	OE3JIS	28 Feb. 95	None
15	JA1BLC	10 Apr. 97	None
16	F5ETM	30 Oct. 97	None
17	KE4SCY	15 Apr. 01	10,18,19,22,23, 24,26,27,28, 29,34,35,37,39
18	N6KK	15 Dec. 02	None
19	DL2AYK	7 May 03	2,10,19,29,34
20	N1HOQ	31 Jan. 04	10,13,18,19,23, 24,26,27,28,29, 33,34,36,37,39
21	AA6NP	12 Feb. 04	None
22	9V1XE	14 Aug. 04	2,5,7,8,9,10,12,13, 23,34,35,36,37,40

CQ offers the Satellite Work All Zones award for stations who confirm a minimum of 25 zones worked via amateur radio satellite. In 2001 we "lowered the bar" from the original 40 zone requirement to encourage participation in this very difficult award. A Satellite WAZ certificate will indicate the number of zones that are confirmed when the applicant first applies for the award.

Endorsement stickers are not offered for this award. However, an embossed, gold seal will be issued to you when you finally confirm that last zone.

Rules and applications for the WAZ program may be obtained by sending a large SAE with two units of postage or an address label and $1.00 to the WAZ Award Manager: Floyd Gerald, N5FG, 17 Green Hollow Rd., Wiggins, MS 39577. The processing fee for all CQ awards is $6.00 for subscribers (please include your most recent *CQ* or *CQ VHF* mailing label or a copy) and $12.00 for nonsubscribers. Please make all checks payable to Floyd Gerald. Applicants sending QSL cards to a CQ Checkpoint or the Award Manager must include return postage. N5FG may also be reached via e-mail: <n5fg@cq-amateur-radio.com>.

*17 Green Hollow Rd., Wiggins, MS 39577; e-mail: <n5fg@cq-amateur-radio.com>

Announcing:

The 2005 CQ World-Wide VHF Contest

Starts: 1800 UTC Saturday, July 16, 2005
Ends: 2100 UTC Sunday, July 17, 2005

I. Contest Period: 27 hours for all stations, all categories. Operate any portion of the contest period you wish. (*Note:* Exception for QRP Hilltopper.)

II. Objectives: The objectives of this contest are for amateurs around the world to contact as many amateurs as possible in the contest period, to promote VHF, to allow VHF operators the opportunity to experience the enhanced propagation available at this time of year, and for interested amateurs to collect VHF Maidenhead grid locators for awards credits.

III. Bands: All authorized amateur radio frequencies on 50 MHz (6 meters) and 144 MHz (2 meters) may be used as authorized by local law and license class.

IV. Class of Competition:

For all categories: Transmitters and receivers must be located within a 500 meter diameter circle or within the property limits of the station licensee's address, whichever is greater. All antennas used by the entrant must be physically connected by wires to the transmitters and receivers used by the entrant. Only the entrant's callsign may be used to aid the entrant's score.

1. Single Op—All Band. Only one signal allowed at any one time; the operator may change bands at any time.

2. Single Op—Single Band. Only one signal allowed at any one time.

3. Single-Op All-Band QRP. There are no location restrictions – home or portable – for stations running 10 watts output or less.

4. Hilltopper. This is a single-op QRP portable category for an all-band entry limited in time to a maximum of 6 continuous hours. Backpackers and portables who do not want to devote resources and time to the full contest period are encouraged to participate, especially to activate rare grids. Any power source is acceptable.

5. Rover. A Rover station is one which is manned by no more than two operators, travels to more than one grid location, and signs "Rover" or "/R" with no more than one callsign.

6. Multi-Op. A multi-op station is one with two or more operators and may operate 6 and 2 meters simultaneously with only one signal per band.

Stations in any category, except Rover and QRP Hilltopper, may operate from any single location, home or portable.

V. Exchange: Callsign and Maidenhead grid locator (4 digits, e.g., EM15). Signal reports are optional and should not be included in the log entry.

VI. Multipliers: The multiplier is the number of different grid locators worked per band. A "grid locator" is counted once per band. *Exception:* The rover who moves into a new grid locator may count the same grid locator more than once per band as long as the rover is himself or herself in a new grid locator location. Such change in location must be clearly indicated in the rover's log.

A. A rover station becomes a new QSO to the stations working him or her when that rover changes grid locator.

B. The grid locator is the Maidenhead grid locator to four digits (FM13).

VII. Scoring: One (1) point per QSO on 50 MHz and two (2) points per QSO on 144 MHz. Work stations once per band, regardless of mode. Multiply total QSO points times total number of grid locators (GL) worked.

Rovers: For each new grid locator visited, contacts and grid locators count as new. Final Rover score is the sum of contact points made from each grid locator times the sum of all grid locators worked from all grids visited.

Example 1. K1GX works stations as follows:

50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

35 QSOs ($35 \times 2 = 70$) and 8 GL's (8 multipliers) on 144 MHz

K1GX has 120 QSO points ($50 + 70 = 120$) $\times$ 33 multipliers ($25 + 8 = 33$) = 3,960 total points.

Example 2. W9FS/R works stations as follows:

From EN52: 50 QSOs ($50 \times 1 = 50$) and 25 GL's (25 multipliers) on 50 MHz

From EN52: 40 QSOs ($40 \times 2 = 80$) and 10 GL's (10 multipliers) on 144 MHz

From EN51: 60 QSOs ($60 \times 1 = 60$) and 30 GL's (30 multipliers) on 50 MHz

From EN51: 20 QSOs ($20 \times 2 = 40$) and 5 GL's (5 multipliers) on 144 MHz

W9FS/R has 230 QSO points ($50 + 80 + 60 + 40$) $\times$ 70 multipliers ($25 + 10 + 30 + 5$) = 16,100 total points

VIII. Awards: Certificates suitable for framing will be awarded to the top-scoring stations in each category in each country. Certificates may also be awarded to other top-scoring stations who show outstanding contest effort. Certificates will be awarded to top-scoring stations in each category in geographic areas where warranted.

Geographic areas include states (U.S.), provinces (Canada), and countries, and may also be extended to include other subdivisions as justified by competitive entries.

Unique, handsome plaques will be awarded to the highest scoring stations. For more information on the CQ VHF Contest Plaque Program see <http://www.cq-amateur-radio.com>.

IX. Miscellaneous: An operator may sign only one callsign during the contest. This means that an operator cannot generate QSOs by first signing his callsign, then signing his daughter's callsign, even though both callsigns are assigned to the same location.

A station located exactly on a dividing line of a grid locator must choose only one grid locator from which to operate for exchange purposes.

A different multiplier cannot be given out without moving the complete station at least 100 meters.

Making or soliciting QSOs on the national simplex frequency, 146.52 MHz, or your country's designated national simplex frequency, or immediately adjacent guard frequencies, is prohibited. Use of commonly recognized repeater frequencies is prohibited. Recognized FM simplex frequencies such as 146.49, .55, and .58, and local-option simplex channels may be used for contest purposes.

Aeronautical mobile contacts do not count.

Contestants should respect use of the DX window, 50.100–50.125 MHz, for intercontinental QSOs only.

UTC is the required logging time.

X. Log Submissions: Log entries must be submitted by September 1, 2005 to be eligible for awards. Submit your electronic log in the Cabrillo format created by all major logging programs. Send via e-mail attachment to <cqvhf@cqww.com>. Subject line: Callsign [used in the contest] only.

Those using paper logs are urged to utilize "web forms," which allows you to transcribe your logs for entry on-line and automatic Cabrillo submission. Web forms can be found at <http://www.b4h.net/cabforms/cqwwvhf_cab.php>.

For those without web access, paper logs may be submitted to: CQ VHF Contest, 25 Newbridge Road, Hicksville, NY 11801 USA. Questions may be sent to <vhf-questions@cqww.com>.

books calendars cds

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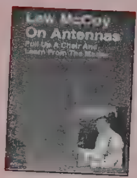
by Lew McCoy, W1ICP



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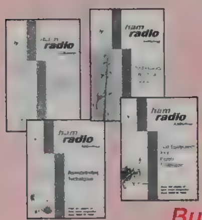

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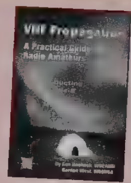

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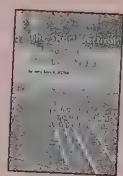

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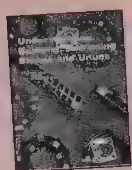

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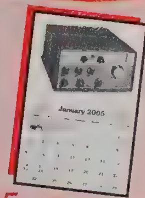

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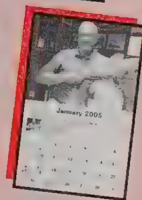

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By Tomas Hood,* NW7US/AAAØWA

PROPAGATION

The Science of Predicting VHF-and-Above Radio Conditions

Nearing the Cycle Minimum

As we move ever closer to the predicted end of solar Cycle 23, sometime between the end of 2006 and the middle of 2007, we expect a relatively quiet sun. We are not seeing the same level of activity that is typical of peak years. However, with the shedding of its complex magnetic structures, the sun continues to give VHF enthusiasts moments to enjoy. The frequent occurrence of coronal holes during March and April brought just a bit of life to 6 meters. Looking at the spots on the OH2AQ DX Summit (http://oh2aq.kolumbus.com/dxs/), a number of North American spots revealed aurora and sporadic-*E* (*Es*)during periods of elevated geomagnetic activity. For example, on April 5, 2005 a number of spots were made not only of Au/*Es* between eastern Canadian and eastern United States stations, but also of video Au/*Es* from Europe into the eastern United States. The estimated planetary *K*-index (*Kp*) rose to 7 for two of the three-hour reporting periods on April 5 due to a solar wind speed over 600 km per second with a moderately southward pointing magnetic orientation. While large auroral events are not common this late in the cycle, enough coronal-hole activity continues to pepper the season with weak auroral propagation openings.

What's even more apparent, however, is that the sporadic-E activity for 2005 promises to be noteworthy. Early in April, reports even on the west coast of North America showed *Es* activity above normal for this early in the year.

On March 30th, Dave Bernhardt, N7DB, in Boring, Oregon (CN85), reported on the VHF reflector (http://www-w6yx.stanford.edu/vhf/), "As I write this report, 6 seems to have died at the moment (0312Z). The opening today was not that unusual for *summer*! You had to look up at the calendar to see how unusual conditions were today. Normally 6 meters is dead from mid-January until late-April/early-May in the Pacific Northwest. Sure, there may be a brief opening here or there, but not one that lasts hours. Besides some very strong signals today, the other interesting characteristic was the time of day that things broke loose. First signals heard here were about 1900Z. Not much unusual today with the solar flux nor geomagnetic activity that I can tell at the moment. Is this an indicator for this year's summer *E* season? We shall see. Another unusual item about most of the contacts today is that they were along the northern tier. Usually we do not see much along this path until later in the *E* season."

*P.O. Box 213, Brinnon, WA 98320-0213
e-mail: <cq-prop-man@hfradio.org>

Sporadic-*E*

Sporadic-*E* propagation is an exciting but mostly unpredictable mode related to "clouds" of highly ionized, dense, small patches in the *E* region of the ionosphere. Ten-meter operators have known *Es* propagation as the summertime "short skip." These "clouds" appear unpredictably, but they are most common over North America during the daylight hours of late spring and summer. *Es* events may last for just a few minutes up to several hours and usually provide an opening to a very small area of the country at any one time.

While there is still a great opportunity for a deeper exploration and understanding of *Es*, a lot has already been learned and observed since it was first discovered in the 1930s. *Es* is known to occur more frequently in latitudes nearer the equator and to peak near the solstices, but it is especially strong in the late spring through the summer.

Over the years, thousands of contacts via sporadic-*E* propagation have been logged on 50, 144, and 220 MHz (not to mention the great amount of supporting evidence from the reception logs of FM and TV station DX hobbyists). In July 1983, the first two-way transatlantic 50-MHz *Es* contacts were made between British and American stations. These contacts were made with only a few watts of RF and spanned the Atlantic Ocean. Since then, many contacts have been made between Hawaii and the east coast of North America, and Japan and the west coast. These proved that *Es* propagation is not limited to one-hop distances. Contacts spanning these great distances were not limited to 50 MHz, but were had on 144 MHz. Even 220 MHz has shown path distances of over 1500 km. (For an interesting discussion regarding normal *E*-layer propagation as compared to *Es*, see <http://www.uksmg.org/elayer.htm>.

Scientists are still pursuing the multiple causes of sporadic-*E*. As far back as 1959, ten distinct types of sporadic-*E* and at least nine different theories of causation were offered. The classification of distinct types has been retained, but since the 1960s the wind-shear theory has become one of the most accepted theories.

Wind shear occurs when the wind blows at different directions and speeds as you go higher up in the atmosphere. Simply, the wind-shear theory holds that gaseous ions in the *E*-layer are accumulated and concentrated into small, thin, patchy sheets by the combined actions of high-altitude winds and the Earth's magnetic field. The resulting clouds may attain the required ion density to serve as a reflecting medium for VHF radio waves. Newer research has revealed a strong correlation between *Es* formation and the passage of the Earth through the trail of debris left by passing comets. The elevated levels of comet "dust" present in the atmosphere as we pass through these comet trails during the summer seem to become concentrated at the *E*-layer heights. With wind shearing and magnetic alignment, highly dense clouds of this debris form, spawning sporadic-*E* propagation.

During periods of intense and widespread sporadic-*E* ionization, two-hop openings considerably beyond 1400 miles should be possible on 6 meters. Short-skip openings between about 1200 and 1400 miles may also be possible on 2 meters.

With the early reporting of *Es* in April, the 2005 *Es* season could very well be exciting. How can we know when a Sporadic-*E* opening is occurring? Several

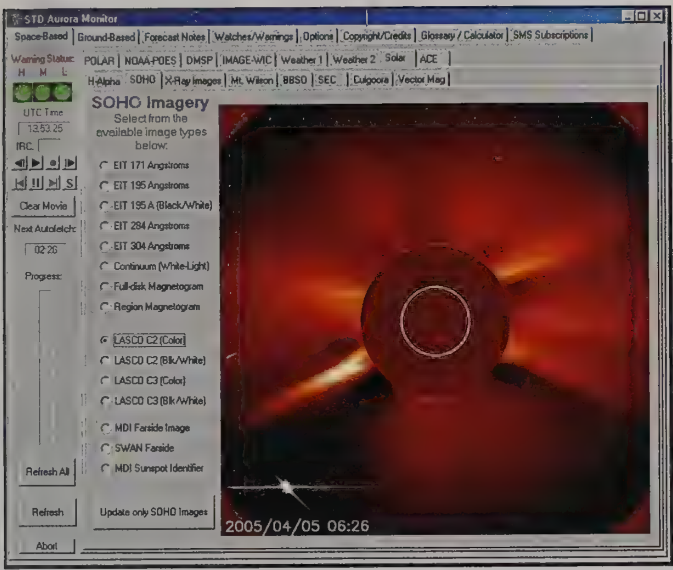

Figure 1. Screen capture of the Solar Terrestrial Dispatch's "Aurora Monitor" software program. This capture shows the SOHO LASCO C2 image from April 5, 2005. The program allows you to follow real-time space weather that impacts aurora conditions.

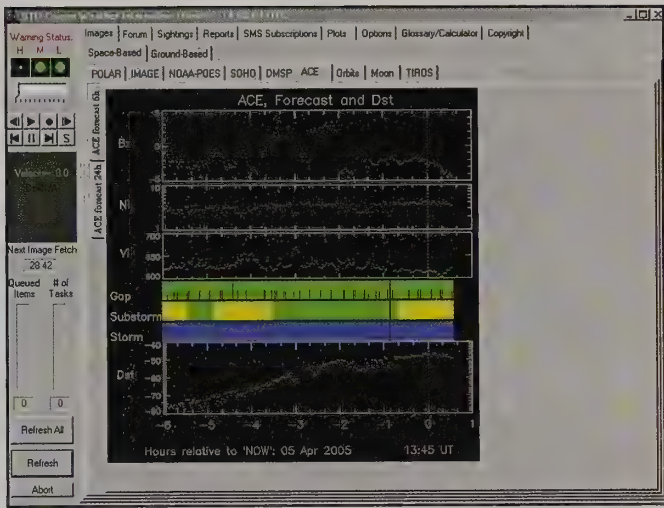

Figure 2. The Solar Terrestrial Dispatch's SWIM (Space Weather Information Monitor) software is a fully customizable browser of space weather information. Not only does it allow you to view real-time images and data graphs, but it also has alert features as well as SMS messaging. This screen capture shows the solar wind data captured on April 5, 2005.

e-mail reflectors have been created to provide an alerting service. One is found at <http://www.gooddx.net/> and another at <http://www.vhfdx.net/sendspots/>. These sporadic-*E* alerting services rely on live reports of current activity on VHF. When you begin hearing an opening, you send out details so that everyone on the distribution list will be alerted that something is happening. They, in turn, join in on the opening, making for a high level of participation. Of course, the greater number of operators on the air, the more we learn the extent and intensity of the opening. The bottom line is that you cannot work sporadic-*E* if you are not on the air when it occurs.

In addition to live reporting, there is a very powerful resource available on the Internet. Check out <http://superdarn.jhuapl.edu/>. SuperDARN (Super Dual Auroral Radar Network) is an international radar network for studying the Earth's upper atmosphere and ionosphere. Using the SuperDARN real-time data 24-hour overview, you can view the day's ionization activity at the northern polar region. You can also view live radar displays of the same area. These graphs help identify *Es* clouds existing in the higher latitudes. One use for this would be the detection of a variation of *Es*, known as auroral-*E*.

For a great introduction to mid-latitude sporadic-*E* propagation, visit the AM-FM DX Resource website <http://www.amfmdx.net/propagation/Es.html>.

Tropospheric Ducting

Scattered reports of tropospheric openings have been made during March and April, but we typically don't see widespread tropospheric ducting until summer. In tropospheric ducting, radio waves are trapped in a type of natural wave-guide between an inversion layer and the ground or between two inversion layers. Ducting causes very little signal loss, and often signals are only heard at each end of the wave-guide. Ducting via the troposphere can propagate signals great distances, such as from Hawaii to California. However, this ducting depends on large weather systems that are more common during the late summer. With the early reports, though, it is worth watching for this mode of propagation.

The term *tropospheric ducting* refers to the stratification of the air within the troposphere. When layers form within this region of air, the refractive index between each layer causes a refraction of VHF and UHF radio waves. If the layers form in just the right way and at the right height, a natural wave-guide is created. A tropospheric duct develops. Ducting is most likely to occur over water during high-pressure, anticyclonic conditions, when the air is relatively still.

As with most matters of propagation, it is not always possible to determine whether tropospheric propagation is ducting or non-ducting. Ducting usually has characteristics like those of sporadic-*E* propagation in that the distant station will be noticeably stronger than closer stations that are not accessible by the duct. Tropospheric ducting results in surprisingly strong signals for the distance. Ducting typically is very geographically selective. Normally stations working a duct are quite close together in space, at both ends of the duct.

Another important issue when trying to decide the mode of propagation across the VHF bands is whether it could have been ionospheric, such as by sporadic-*E*. Generally, sporadic-*E* will be much stronger on similar bearings when you listen to lower frequencies. If there is no sign of any enhancement of propagation on lower VHF frequencies, you usually can be quite confident that the mode was tropospheric.

Advanced visual and infrared weather maps can be a real aid in detecting the undisturbed low clouds between the West Coast and Hawaii or farther during periods of intense subsidence-inversion band openings. This condition also occurs over the Atlantic. There is a great resource on the Internet which provides a look into current conditions. Bill Hepburn has created

forecast maps and presents them at <http://www.iprimus.ca/~hepburnw/tropo_xxx.html>, including maps for the Pacific, Atlantic, and other regions.

If you know that conditions are favorable for tropospheric ducting in your area, try tuning around the 162-MHz weather channels to see if you can hear stations way beyond your normal line-of-sight reception. It is possible to hear stations over 800 miles away. Amateur radio repeaters are another source of DX that you might hear from the other end of the duct.

These openings can last for several days, and signals will remain stable and strong for long periods during the openings. The duct may, however, move slowly, causing you to hear one signal well for a few hours to then have it fade out and another station take its place, from another area altogether.

Meteor Showers

The *Eta Aquarids* meteor shower will occur in May. It will peak during the morning of May 5th, but start around April 19th. This shower is expected to have a peak rate of up to 60 per hour this year. It is expected that the shower will have a broad period of maximum activity, starting as early as May 3rd and extending out to May 10th. Also, because of the low radiant, the meteors tend to have long ionized paths, making for strong signal reflections. Look for 6- and 2-meter openings off the ionized meteor trails.

There are some other showers in May that may yield some propagation. These include the *Epsilon Arietids,* which should peak on May 9th; the May *Arietids,* peaking on May 16th; the *Omicron Cetids,* peaking on May 20th.

June has a few showers, as well. The *Arietids,* which is active from about May 29th through June 19th, has a peak that tends to blend with the *Zeta-Perseids* shower, which starts around May 20th and lasts until early July. These two showers may combine this year to produce a very strong radio event around June 9th.

July has only minor showers. These showers typically have not yielded much radio activity. For more information on them take a look at <http://www.imo. net/calendar/cal05.html>. Also check out <http://www.meteorscatter.net/metshw.htm> for a very useful resource covering meteor scatter and upcoming showers.

TE Propagation

A seasonal decline in TE (transequatorial) propagation is expected during May. An occasional opening may still be possible on VHF. The best time to check for VHF TE openings is between 9 and 11 PM local daylight time. These TE openings will be north-south paths that cross the geomagnetic equator at an approximate right angle.

The Solar Cycle Pulse

The observed sunspot numbers from December 2004 through February 2005 are 17.9, 31.3, and 29.1. The smoothed sunspot counts for June through August 2004 are 41.7, 40.2, and 39.3, all showing the steady decline of Cycle 23.

The monthly 10.7-cm (preliminary) numbers from December 2004 through February 2005 are 94.6, 102.4, and 97.3. The smoothed 10.7-cm radio-flux numbers for June through August 2004 are 107.2, 105.9, and 105.

The smoothed monthly sunspot numbers forecast for May through July 2005 are 18.7, 17.0, and 15.8, while the smoothed monthly 10.7-cm is predicted to be 82.4, 79.8, and 77.6 for the same period. Give or take about 15 points for all predictions.

The smoothed planetary *A*-index (*Ap*) numbers from June through August 2004 are 14.0, 13.8, and 13.8, showing an overall plateau in geomagnetic activity during the summer season of 2004. The monthly readings from December 2004 through February 2005 are 11, 22, and 11.

(Note that these are preliminary figures. Solar scientists make minor adjustments after publishing, by careful review).

Keeping a Pulse on Space Weather and Propagation

For those of us who want to keep a close watch on space weather by viewing the latest solar images and the various instrument readings such as solar wind speed or the planetary *K*-index, the Internet has proven to be an invaluable resource. As I have mentioned before, I created a website collection of these near real-time images and graphs at <http://prop.hfradio.org/> (for cell phones and wireless devices with Internet browsing capabilities use <http://wap.hfradio.org/>). Others have created similar pages. The folks at the Solar Terrestrial Dispatch (http://spacew.com/) have not only created online resources, but also provide a few computer programs that can be quite useful. Known for their powerful propagation forecast and modeling software, Proplab Professional Version 2.0 at <http://www.hfradio.org/swp_proplab/> (they are working on a new graphical version) has also created an Aurora Monitoring Software program as well as a more exhaustive SWIM program. SWIM, or Space Weather Information Monitor, is like a Swiss Army knife. It not only comes with an exhaustive default collection of resources, but allows you to customize the program and even add new resources.

Both the Aurora Monitoring Software and the SWIM program act as a dedicated "browser" of space weather information. They automatically download current solar images, space weather data, and other information, and organize all of this into a self-contained package that is easy to use. They even have alerts that can aid in spotting conditions that might trigger the kind of propagation you are hoping for. Take a look at both packages. The Aurora Monitoring Software is at <http://hfradio.org/swp_stdaum/>, and SWIM is at <http://www.hfradio.org/swp_swim/>.

Also don't forget to follow the research and online collection of Dr. Volker Grassmann, DF5AI. His excellent Amateur Radio Propagation Studies website (http://www.df5ai.net/) is a library of cutting-edge research and a wealth of knowledge on the VHF world of propagation.

Feedback, Comments, & Observations Solicited!

I'm hungry! I need your feedback. How is this column helping you? Are there questions that you would like to see me explore further? Do you have exciting research that would be helpful to other readers? Please send your reports, questions, and ideas to me via e-mail, or drop me a letter. I look forward to hearing from you. You are welcome to also share your reports at my public forums at <http:// hfradio.org/forums/>. Up-to-date propagation information is at my propagation center at <http://prop.hfradio.org/>, or at <http://wap.hfradio.org/> for wireless devices. Until the next issue, happy VHF DXing!

73 de , Tomas, NW7US

By Chuck Houghton,* WB6IGP

Components for 10-GHz and Up Transceivers

Well, here we are. I never thought I would be talking about working 47-GHz using some sophisticated junk-box parts. However, surplus material is available, and with a diligent search of surplus outlets you can obtain components that can be assembled into a working transverter as will be described here. This was our first attempt. It's rather crude, but it works, which shows that the construction of a simple homemade mixer for 47 GHz is possible.

It was not an overnight collection binge that started the effort, but rather a slow process aimed in this direction. Collecting material for a project takes time, especially when you are not ready to sell the family farm to purchase the parts needed. Most of the material used in this project can be obtained in ready-made kit form, and the kits are quite good. However, that is costly. We chose another avenue, and that was to sit and wait for the parts to come our way. The idea was to slowly gather the components to construct a microwave transverter. All you need is some luck in locating key parts and the time to find the components needed. Take, for example, my first SSB transceiver for 10 GHz.

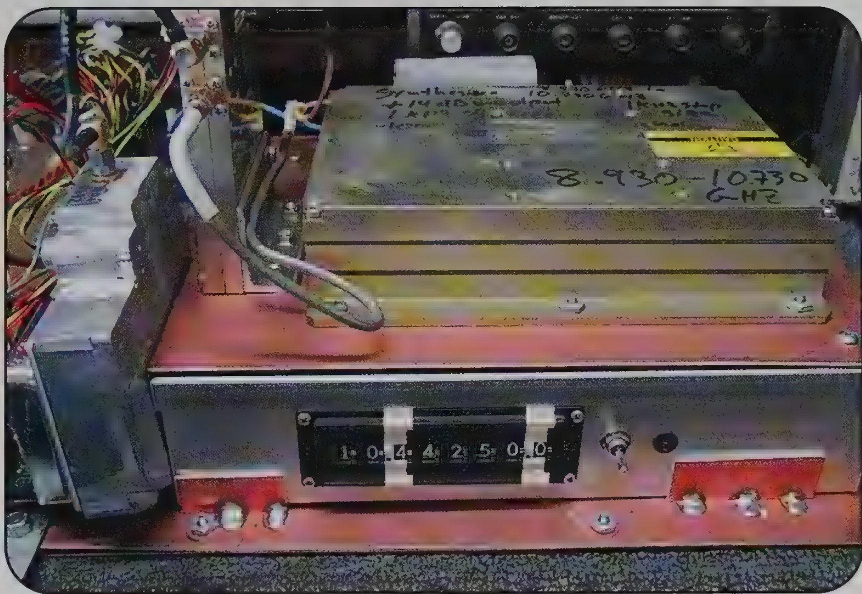

Photo A. Front view of 47-GHz rig. The synthesizer is at the top right, sitting on top of the BCD controller chassis. The synthesizer is capable of operation from 8930 to 10730 MHz with +14 dBm output. Frequencies in as fine as 1-kHz steps are set throughout the frequency range and are controlled by BCD switches on the front panel in conjunction with the 10-MHz internal clock oscillator. Close-in phase noise of the synthesizer is better than –90 dB.

An SSB Transceiver for 10 GHz

The SSB rig was assembled using a surplus TVRO RF preamp, a mixer found at a local swap meet, four SMA relays, and a Frequency West microwave "brick" oscillator. Additional material included a 10-watt TWT (traveling wave tube) power amp and TR switching control with time delay for transmit relays. The time-delay control board was the idea of Kerry, N6IZW, and he designed it with receiver protection circuitry, allowing the TX relays to be slow to operate and fast to release, with the reverse for the RX relays. This way the receive preamp was protected from the transmitter by switching times. It allowed the receive relay to release from the antenna before it operated the transmitter relay. This circuit was constructed dead-bug fashion, although I made a circuit board for it. I never installed it, though. The 10-GHz rig is still wired that way after ten years. I should have revamped the circuit with PC boards, making it more reliable and better looking as well.

This rig has withstood the test of time. It has even survived my grandsons' tinkering with it. I had mounted the 10-GHz rig in an old BC221 surplus WW II frequency-meter case in my grandsons' tree fort in our backyard, pointing it at a local mountain for reflection contacts on 10 GHz. With their sandbox under the fort, the kids filled the outdoor case with about 25 pounds of sand. Needless to say, some shaking out was needed and I thought it was a goner. It took a while to dump all the sand and vacuum it out, but it's still working just fine now, with a lock on the case. This little episode demonstrated certain reliability in construction even back then in my early years of putting surplus parts together. I still can imagine the effort it took to haul all that sand up into the tree fort and dump it carefully into the muffin-fan exhaust hole. There still is sand embedded in the RTV used to harden the circuit boards, using the RTV like a potting compound to protect the wiring and component parts. The rig is still switched by the original four SMA relays

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Photo B. Top view of the 47-GHz rig. The Verticom synthesizer is to the right. The 2640-MHz synthesizer is at the bottom left in the aluminum cutout shield compartment. The Pecom 23-GHz TX module is just above the 2640-MHz synthesizer. The switching regulated power supply is to the far left, with the cooling fan in front of the power supply.

controlling a TWT 10-watt amplifier and a series of two RF preamps (one preamp to drive the TWT).

The unit was a collection of quite a few components all scrounged from surplus dealers or swap meets and assembled over time.

The 24-GHz Transceiver

Establishing a station on 24-GHz SSB was quite unexpected, as my steady hands and eyesight are not that of my younger years. I put off that project until the time was right and waited to collect parts the economical way. However, a most unlikely set of circumstances presented itself in the form of a transverter that was sold as part of an estate sale. I could not turn down the offer of a complete transceiver fully modified from surplus. It was a 24-GHz Pecom unit modified by Sam Lutweiler, K6VLM (SK), of the San Bernardino Microwave Society (SBMS). Obtaining the completed transverter would help in tracing out his conversion details.

I undertook this project; as I was involved in helping to obtain quite a large quantity of these surplus Pecom units. We obtained two different types of transverters that were what we call high side LO (local oscillator) injection and low side injection. The low side injection had a capability of operation at 23.525 GHz unmodified in the TX module. (This TX module will become a critical component of a rig for 47 GHz.) To put things in perspective, I was still tracing the circuitry of these units from our surplus haul at the time when Sam had already modified two Pecom transceivers for 24.192 GHz and had installed one on top of his roof for operation. We had a long phone call with Sam describing the modifications he developed. I tried to take notes and keep up with him. I wish I had used a tape recorder to record Sam's conversion technique, as the next I heard he had passed away. That left us to put together the hardware and notes to document his conversion.

Of primarily interest were the modification and construction techniques used by Sam in his conversion. Sam had accomplished this conversion with great success. As complicated as Sam's process seemed to me at the time, it demonstrated his deep understanding of conversion process for the Pecom units. We were fortunate enough to obtain a transceiver and a box of papers, which had some raw conversion details on procedures he had used in his modification process. For example, Sam's test sketch showed his scheme to mix two signal generators, one at 18 GHz and the other at 6 GHz, to align filters on the PC boards, as he did not have a 24-GHz generator.

Making a 47-GHz Transverter

In the meantime, Kerry, N6IZW, also was working out his conversion methods on the Pecom modules for a 24-GHz transceiver, and he observed another use for the TX module. He saw the relationship of the frequencies used in the unmodified 23-GHz transmit module. In its original configuration it was driven by a 9-GHz LO and had an IF frequency of nearly 3 GHz. This observation presented some interesting possibilities for its use on 47 GHz. With a 10.44250-GHz LO drive, which is doubled in the Pecom TX module mixer, and with IF drive of 2.640 GHz, an RF output of 23.525 GHz is produced. This method allows the Pecom TX module to operate nearly stock, driving a final output mixer, doubling the drive (23.525 GHz $\times$ 2 = 47.05 GHz). This was used with a 2-meter IF of 145 MHz, giving 47.195 used with the final mixer doubler circuit. (This mixer doubler is home constructed and nothing special, showing Kerry's thinking out of the box with this harmonic generator, or mixer.)

LO driving the two anti-parallel diodes attached to a section of 141 coax, or on the back of an SMA connector by themselves, makes a great harmonic multiplier. Adding the fine wire makes an RFC (radio frequency choke) to couple to the IF port of a mixer for an IF frequency used at 2 meters.

A little figuring revealed that by using components on hand the following could be constructed and given a try. Working backwards, if we used 47.05 GHz for an LO, that divided by 2 equaled 23.525 GHz (the Pecom TX unit driver output). We had 2.620-GHz Qualcomm DRO (dielectric resonant oscillator) synthesizers on hand, and we used a modified one for 2640 GHz to be the IF input driver on the Pecom TX converter. That meant that 23.525 GHz, the TX output, minus 2.640 GHz equaled 20.885 GHz, which is twice the input drive LO to the TX module. Dividing that by 2 equals 10.44250 GHz. Other frequencies are possible as well. It just depends on what you have on hand.

This IF synthesizer is a surplus Qualcomm DRO PLL board and is available from the author, should the stock fre-

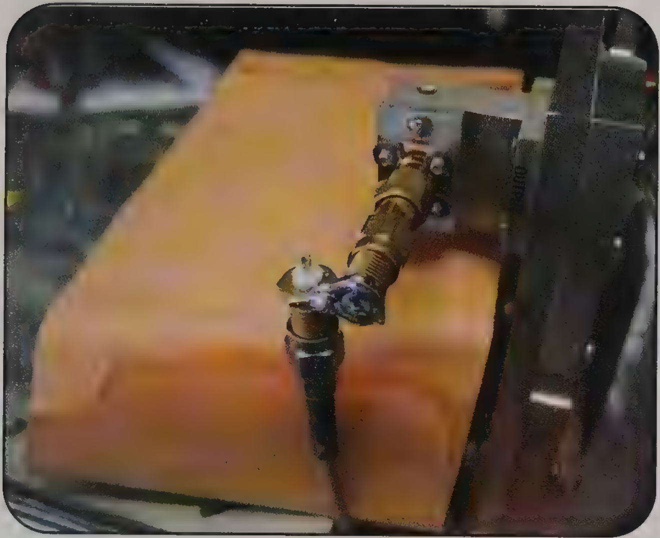

Photo C. Close-up of the 47-GHz system mixer showing the tiny diodes (you can barely see them) and IF cable (145 MHz) and SMA connector pointing downward in the original test configuration. This was the first design.

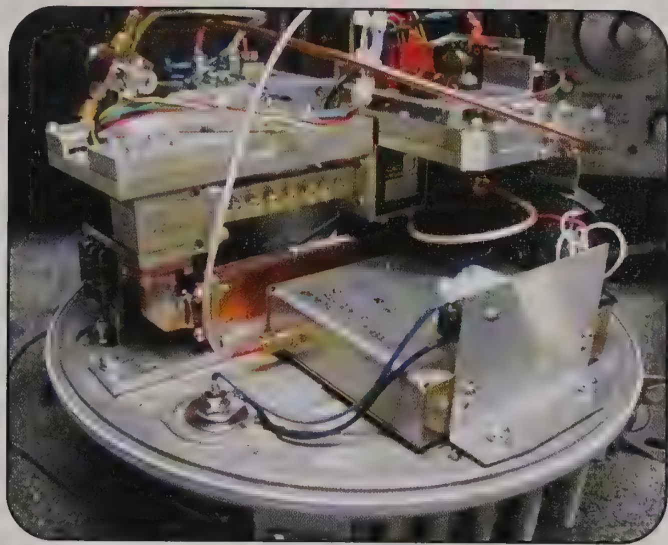

Photo D. Side view of the modified Pecom 24-GHz rig completed by Sam, K6VLM. In the center is same 23-GHz TX module used in 47-GHz rig. The module behind the TX unit on the multi-screw waveguide receive filter is the receiver module.

quency work out for your LO and IF drive requirements. Stock, it functions on 2.620 MHz and is quite easy to convert in the range of ±50 MHz of the original 2620-MHz frequency. As we needed 2640 MHz, it proved to be quite easy. With a DRO synthesizer, not every desired frequency is easy to modify to a new frequency. Some synthesizers are more flexible than others.

The DRO synthesizer was an easy fix for the IF drive required. However, the 10-GHz synthesizer we obtained from surplus was the crown jewel and could be termed unobtainable. It was manufactured by Verticom and is capable of 1-kHz parallel, simple BCD (board chip definition) switching of frequency from 8.3 GHz to 10.7 GHz in 1-kHz frequency steps (its Verticom part number is MTS-2000), a very lucky find. (Note that there have been many Verticom synthesizers on eBay, but all I have observed is model 1500, which has a 150-kHz step (or other unknown frequency steps, and they require suitable serial programming with a processor or stamp board). If you find an MTS-2000 synthesizer in a frequency range suitable for your rig, I suggest you grab it.

Other than the power supplies, dish antenna, synthesizer, or source of a local oscillator and a mixer for 47-GHz, this rig could be constructed with the major item being the TX module from the 23-GHz Pecom transmitter. Using a flexible synthesizer that can be set up in 1-kHz steps made the main LO task simple. A Frequency West brick or other LO could be used here. We used the Agile Verticom Synthesizer, as it was in the junk box and it operated from 8.930 GHz to 10.700 GHz—just right for the required 10,442.50-MHz LO drive. Used with the Qualcomm 2.620-GHz synthesizer (now modified to 2.640 GHz; Pecom IF In/Out) it gave an output at 23.525 GHz right in the normal operation range of the TX module. With 100-mw (+20 dBm) drive (Pecom output) at 23.525 GHz to inject into the LO port of a home-built mixer constructed from two anti-parallel diodes (doubler), this gave us 47.05 GHz.

Using a 145-MHz multimode transceiver as the IF RX/TX source produced an operational frequency of 47.195 GHz. The 2-meter transceiver was set to 250 mw output, 1/4 watt, and an 8-dB attenuator was attached between the transceiver and the microwave mixer. This reduced the transmit power to +7 dBm output drive to the IF mixer port. Total mixer power being used was the LO at +20 dBm; IF drive on transmit of +7 dBm seemed a little high, but we went for the gusto and when tested it seemed to function very well. Besides, we had replacement diodes in the form of PC boards from surplus material to obtain new mixer diodes should that be needed.

A trial at Kerry's QTH during the San Diego Microwave Group's monthly meeting was our show-and-tell portion of the system check. It was a "go for the gold" effort. The first test on the workbench at 2 feet initially showed that something was very wrong. We were receiving signals every 25 kHz up and down the band. A check with the spectrum analyzer traced it to my 2-GHz synthesizer DC power supply 10-volt line. It seems that the 7810 10-volt voltage regulator was oscillating and needed better filter cap action. Replacing the 10-mFd bypass cap with a 100-mFd cap removed the offending ripple on the DC feed and greatly cleaned up the synthesizer output.

Testing the transverter over this 3-foot path proved simple and produced a great note for CW, almost as good as you can get. As a simple test we tried SSB on Kerry's 2-meter multimode IF driver. I switched to SSB on my Yaesu FT-817 and clarity was just as good as 40 meters during the best of times.

This was a contact on 47 GHz, and what fun it was. It was like putting together your first crystal-detector set.

Just for added fun we decided to increase the distance, as we were using AC power supplies for the rigs. We patched in a 75-foot extension cord and walked out of the garage and down the driveway still operating SSB between Kerry and myself. Signal levels were still in the S8+ region. Moving the 10-GHz synthesizer 10 kHz in frequency (it is multiplied by 4 in the rig) moved the IF frequency 40 kHz, as expected.

Also, later that evening Kerry placed a 40-GHz waveguide in the system to

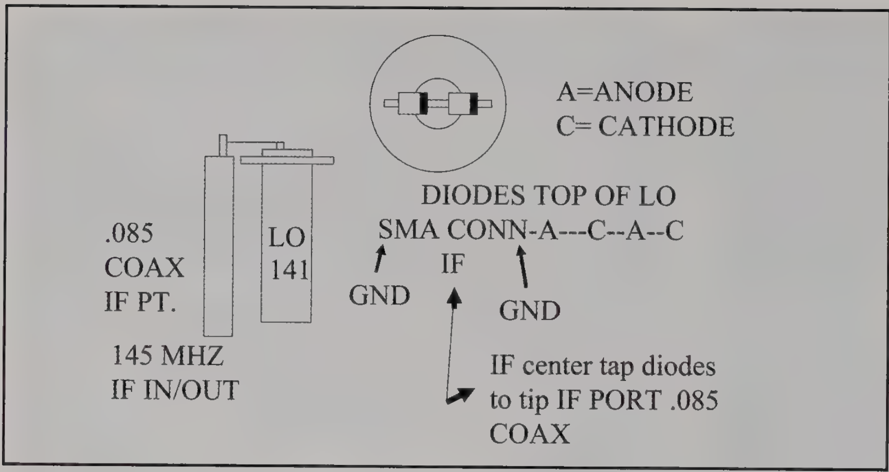

Figure 1. Mixer construction /placement of microwave diodes on the back of the SMA bulkhead connector. Use the shortest possible lengths. We used a bare mixer for a short SSB contact on 47-GHz at a meeting of the San Diego Microwave Group. This mixer, while not an optimum design, is shown here to demonstrate how simple a mixer can be. It's just a starting point in design and it worked.

ensure that it was not 23-GHz overload of the receive mixer and that signals were still functional, proving to our satisfaction that we really were on 47 GHz. After all, we had to use these procedures, as we did not have 47-GHz test equipment and an alternate method had to be used to demonstrate what was going on.

It took time and effort, but the transceiver was assembled all from surplus parts. Several issues still remain, though. Small dish antennas are needed to allow greater operating range. DC power supplies should be added to make the rigs portable. The AC switching power supplies initially were used because they supplied +5 volts, in addition to +15 volts, and these were adjusted to 5.2 volts and 15.6 volts on the +15-volt supply for the YIG (yttrium iron garnet) synthesizer requirements. A bank of voltage regulators for –5 volts, and +10 and +12 volts DC for other circuit requirements, was derived off the switching power supply's + and – 15-volt output taps. It's a little crazy to use a switching power supply capable of 40 amps at 5 volts, but it is good for our power needs and it was in the junk box.

This multi-voltage output power supply made the power-supply issue only a matter of connectors and a slight voltage readjustment to up the 5- and 15-volt lines a few tenths of a volt for synthesizer requirements. Other changes might be to remove the synthesizer control BCD switch box and hard wire the YIG synthesizer control circuitry, greatly reducing the size of the rig. There are lots of possibilities, as there are still other junk boxes to check or we just might find what we are looking for if we sit back and wait for it to land in our lap.

The power supply, like most other items, was obtained surplus from a local scrap-metal junkyard. The Pecom transceiver was obtained surplus for $20 from another scrap-metal yard in the Sunnyvale, California area. The Verticom synthesizer was obtained surplus as well, a find about which I am still amazed. I feel very lucky that we were able to obtain it for our microwave group. Like all rare items, it was one of several key items used in the construction of the converter for 47 GHz—easier than a Frequency West brick.

I forgot to mention the dish reflector we first used. It was a flashlight reflector from a RadioShack lantern. Later reflectors used were stoplight reflectors of the 6- to 8-inch variety, and the latest is a Pecom 39-GHz commercial reflector about 12 inches in size.

One of the photos shows the synthesizer sitting on top of the BCD switch controller for the parallel input control to the synthesizer programming data lines. Inside the controller is an external 10-MHz OCXO (oven-controlled crystal oscillator) reference oscillator. Next to the muffin fan on the bottom left is the Qualcomm DRO synthesizer set to a fixed 2640 MHz. The module standing on its edge is the Pecom TX transmitter module for 23 GHz.

The 47-GHz mixer is the part of the system that was home built. The mixer consists of two SMA bulkhead coax connectors, one modified to accept two microwave diodes on its back face and the other to serve as 145-MHz IF port. The diodes used were scrap from Qualcomm transceivers for 14-GHz. Using a heat gun, we removed the diodes from the original PC-board 14-GHz mixer. The performance at 47 GHz, while not the very best, was quite good in this frequency application, especially considering the cost. As with all of the other material we picked up for this project, the diodes for the mixer were surplus.

Mixer Modification

The bulkhead SMA connector's Teflon® is cut off flush with the back of the SMA flange. Also, the center conductor of the SMA connector is cut off nearly flush with the back of the connector. Next a second SMA connector is soldered to the first connector to make the structure rigid. Use .141 hardline to support both connectors and form the mixer towards the focus point of a small dish.

The mixer is not difficult to construct. Two diodes are required. One diode is soldered one end to ground and the other end to the nub of the center conductor of the SMA connector centered about a straight line from 9 o'clock to the center pin (anode to ground, cathode to the center pin). The second diode is soldered anode to center pin in line from the center pin to 3 o'clock and cathode grounded. Leads should be kept as short as possible, with the diode lying flat against the flange back of the SMA connector.

To test to see if the diodes survived the handling and soldering, measure with a VOM on diode check or use the X10 scale of a VOM. Measure from center pin to ground and you should see a diode junction forward resistance. Reverse the meter leads and you should see the same junction resistance to ground on the second diode, which is connected in an anti-parallel configuration. Now with the two diodes connected and testing good, make the IF port by connecting a single strand of the finest gauge wire you can find. I used a single strand of 110-volt AC lamp cord and soldered one end of this single strand to the diode center connector. The other end was soldered to the IF port, which is constructed out of .085 hardline. Make connection to the center conductor of the .085 hardline coax IF port. The

other end of the .085 coax has a SMA connector for IF connection. This is the 2-meter IF port. The drive from the Pecom TX module output at 23.525 GHz is the input LO port of the mixer.

The RF port is somewhat unconventional. It is focused, the RF mixer diodes and IF port all directed to a small reflector dish for testing. On Kerry's rig he had a 4-inch dish, and he pointed the mixer diodes into the focus point of the dish for testing. The diodes and SMA connectors were supported by .141 coax hardline, positioning the mixer diodes to the focus point of the dish. This was the first-cut design and has been improved through the great efforts of Don Nelson, NØUGY.

The improved design consisted of drilling a hole in the LO SMA connector to couple the IF port out. The circular waveguide was placed over the diodes and soldered to the top of the LO SMA connector to create a rigid structure, coupling to a circular waveguide and small 47-GHz splash plate at focus. For full details on this improved mixer, look on the web at <http://www.ham-radio.com/sbms/sd/projindx.htm>.

The mixer also has harmonic-generating possibilities. Driving it at much lower frequencies into a single or even two diode arrangement works very well. This mixer has been shown to have great harmonic-generating capabilities. Frequency markers from lower frequency oscillators have been observed as high at 10 GHz and low at 24 GHz. The diodes used were "fly spec" size diodes (quite small). They were used in commercial applications for 14 GHz, so they already exhibited great microwave capabilities and were in a Stripline package, which permitted us to solder them to the back of a SMA connector.

This was the simplest test and evaluation. The next test came from Don, N0UGY, who put quite a bit of time into improving the mixer and making a mixer waveguide output to cut off the 24-GHz LO feed and only pass the 47-GHz signal-mix product from this simple mixer.

The waveguide was .188 ID diameter hobby brass tubing telescoped into a second section of brass tube stock. This slightly larger brass tube stock fit the OD diameter of the .188 ID stock and was soldered around the diode mixer and SMA connector rear, enclosing the mixer diodes in a launch sort of short section of brass tubing. The end of the .188 diameter tubing was a long section of tube length, and two slots were cut into the tube end. A very small splash plate was soldered onto the far end of the small tubing. The splash plate was placed at the dish focus point in a more conventional design.

My thanks to Don for his efforts in making this great improvement to Kerry's original mixer design. I don't want to cover all the design notes Don provided, but rather I'll let him release his improved design.

Kerry and I have made contacts over 1 km during the 10 GHz ARRL contest with lots of signal to spare. Improvements have been made, incorporating 8-inch stoplight reflectors with greater distance capabilities, and plans are in the works to adapt a better dish antenna from a 39-GHz Pecom system that we have on hand. The junk box delivers again.

Summary

Even though we made use of some sophisticated components, I hope we have shown that a project can be successfully and inexpensively completed using surplus components, items in a junk box or two, and homebrew construction. As always, if you any questions, please e-mail me at <clhough@pacbell.net>.

73, Chuck, WB6IGP

OP ED

One Reader's Opinion

The Good Old Days?

By John Mollan,* AE7P

Many newspapers around the U.S. print a page entitled "Op Ed." This usually runs opposite the editorial page; hence its name. Sometimes the name takes on a double meaning, when the author has a viewpoint opposite to the editor's. Its purpose is to give a writer an opportunity to express a view or propose an idea for discussion in a longer format than what is normally found in a letter to the editor. There are many views and ideas floating around in the world of VHF that are worth considering and discussing. Please note that the views expressed herein are those of the author and do not reflect the views of CQ VHF *or its editorial staff.* —*N6CL*

When we were children, we often heard grandpa speak of the "Good Old Days." It was a time when you knew your neighbors. Things were simpler. People were more honest. Apparently, life was better. While nostalgia is never viewed with 20/20 hindsight, it is often entertaining to view those early days of radio and the excitement they provided.

It is not necessary to go back 60 or 80 years to view some of these times. Just 30 years ago things were happening that would revolutionize ham radio. The early 1970s would witness the introduction of solid-state 2-meter transceivers, simple mobile operation, and the dominance of the repeater.

Until that time 2-meter communications were highly experimental. A variety of modes and equipment could be seen. Converted taxicab radios brought some static-free FM activity to the band. There were a variety of AM transceivers around and a few souls on CW and SSB. Some hams had converted GE Progress Line (Prog Line) transceivers for use on the band. There were even some Heath "Twoers" still in use. Most of the existing rigs were tube-type, quite heavy, and awkward to operate. Nearly all were crystal controlled.

Mobile operators could be spotted by the halo antennas mounted on their back bumpers. Horizontal polarization dominated 2-meter operation. Nearly all communication was point to point and the horizon marked the limit of communication in many cases.

FM operators soon established some simplex calling frequencies. The first in common use was 146.94 MHz, which was used by most hams with FM capability. A mobile operator using this frequency was nearly assured of a response if he put out a call. Hearing an out-of-town mobile operator always brought about a reply and often an invitation for dinner.

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The 1970s-vintage Heathkit 202.

Because of the limited range of simplex operation, many clubs and individuals began erecting repeaters on nearby hilltops, water towers, or nearly anyplace that gave some height advantage. The granddaddy of all repeater frequencies was 146.94 MHz with an input frequency 600 kHz lower. This was known to all as the "three-four-nine-four" repeater. Soon a number of other repeaters would appear in the 146–147 MHz section of 2 meters, spaced 60 kHz apart to prevent interference. This was one of the first successful instances of channelization in the ham bands. Nearly all repeaters were open, with carrier-operated receivers.

During this same period, a number of manufacturers introduced a variety of mobile, crystal-controlled FM transceivers. Most rigs ran 10 watts, enough for repeater operation in metropolitan areas. The number of channels varied from less than 10 to a whopping 22. A separate crystal was used for transmit

Because of its hot receiver, the ICOM IC-22A was the envy of all.

The Gonset 2-meter Sidewinder.

and receive on each frequency. The cost of purchasing all 44 crystals for a 22-channel radio might exceed the cost of the radio itself! A number of manufacturers advertised their 2-meter equipment in ham magazines. Some of this manufactured equipment was converted from commercial or aviation use. Many of these manufacturers no longer make ham equipment. Because of its hot receiver, the ICOM IC-22A was the envy of all at the time.

Most of the early FM transceivers were easy to operate. My first rig, a Genave GTX-10, had three knobs (volume, squelch, and channel) and no meters. Even the microphone was hard-wired in!

With just a half-dozen common repeater pairs installed in his radio, a ham could drive across nearly any section of the United States and receive a prompt answer to his (or her) "monitoring" call. If there was anyone listening to the frequency, you would receive a friendly response and an opportunity to chat. New friends were made and there was much excitement about this new mode. You soon found out where certain hams "hung out."

As the years passed, the number and sophistication of transceivers and repeaters multiplied. Devices to limit access, such as PL tones, were installed. Radio manufacturers soon developed synthesizers that would cover the entire band and several modes. Power levels increased. Soon you could operate on any frequency of your choice. Some radios covered more than one band! Features that were unimaginable in the 1970s were soon offered on the most basic radios. Consequently, the most essential accessory to possess was the operating manual for your radio!

However, as the level of technical sophistication has increased, the actual amount of communications between strangers has declined. Today an out-of-town operator may have difficulty discovering the frequency and access tones of a local repeater. Even if the repeater is accessed, most "monitoring" calls do not get a response. It is only in the more sparsely populated areas of the country that one can routinely receive a response when a repeater is accessed. A call on the simplex calling frequency of 146.52 MHz rarely is answered.

What made those "Good Old Days" of the '70s so special? It was not the price of the equipment. Today's 2-meter radios can run circles around those early rigs at a fraction of the cost. Perhaps we are victims of our own technical sophistication. It is the feeling of camaraderie among hams that seems to be the missing element. Perhaps the number of hams on the air has made the hobby less exciting. Perhaps we are just "too busy" to deal with strangers. Perhaps we should just remember those simpler times. ■

The "Minor" Spring Equinox Sporadic-E Season of 2005 *(from page 9)*

confirming the first-hop *Es* link from the Florida panhandle area on to TEP. The stateside reports showed extensive *Es* over the southeast USA. Thus, conditions were favorable for multi-hop *Es* links to the TEP zone. I believe the northern boundary of the TEP zone on March 2nd was along a line extending from KP4, HI, and 6Y. This boundary may have been farther south, as ZP6CW did not spot any KP4s. KE4WBO (EL96) spotted the YV4AB beacon at 0300 UTC. That is two-hop *Es* from Florida. One wonders if it could be perhaps even two- to three-hop *Es* for the TEP links.

The map in figure 4 shows the value of posting loggings, even if it is not for "DX." Savvy 6-meter operators can plot the *Es* paths and see if a path may be open. Tim Havens, W4TRH's DXers.info site has a map utility built in. I use it along with plotting my own maps during openings.

The 6-meter band closed to Florida at around 0300 UTC. It remained open out west to Arizona from WØ until after 0700 UTC! K7TOP spotted the WBØRMO beacon (EN10) at 0737 UTC! Had 6 meters gone mad?

The 6-meter *Es* continued the afternoon of March 2nd. With the DX contacts reported, and the potential to work new countries, interest was now very high among 6-meter DXers. The *Es* openings were reported started at 2230 UTC and were mainly between Texas, Florida, etc. On to March 3rd, and the *Es* continued until after 0530 UTC! Most activity was among W4, W5, W6, W7, and WØ. I did not see any "*Es* link"-type contacts spotted. Driving home from Salina, Kansas that evening, I had nice chats with KK4TE (EM50) and WØMTK (DM59) while mobile near McPherson, Kansas on Interstate I-135. There were 20+ hours of *Es* so far for March 2005.

On the afternoon of March 3rd there were more 6-meter *Es* openings for the western states and Mexico. Starting at 1815 UTC, stations in California, Arizona, and XE2MX worked Oregon and Washington State. The opening for the western states continued past 2200 UTC, with KE7V (CN88) working W7JLC (DM34) at 2204 UTC. March 4th, UTC, there were scattered *Es* openings from AD6W (DM06) to KC7UUN (DN53) at 0250 UTC. Add another five hours of *Es* to the total.

On the afternoon of March 5th on into March 6th, a minor geomagnetic storm began with aurora worked along the northern tier states. No *Es* QSOs were spotted that I could find. Aurora activity usually "dampens" mid-latitude *Es*. The next morning, however, the aurora seemed to "spark" the *Es* again.

March 6th: More *Es*

Es began at around 1400 UTC between W1, W3, W8, and W9 and Florida and the Bahamas. This opening continued to around 1800 UTC. That afternoon and evening more aurora was reported.

March 7th: LW3EX Spots W3DOG/b

March 7th was mostly quiet for *Es*. *F2* and TEP were going strong for the South Americans. At 2310 UTC, Walt, LW3EX, spotted the W3DOG beacon in FM28. Could this perhaps have been an *Es* link to TEP?

March 8th: *Es* to Costa Rica from Florida, ZP and PY to Florida

On March 8th, K4RX had ZP6CW at 599 at 0038 UTC, along with PY1RO. Were these *Es* linked or direct TEP? On this date KD4ESV was hearing the TI2NA beacon in via *Es* at 0134 UTC. Sam, KD4ESV's *Es* spot might suggest an *Es* link for Terry, K4RX's South American contacts.

March 9th: *Es* Arizona to Mexico

Barry, K7TOP (DM43), in Arizona, worked XE1KK and XE1MEX at around 0255 UTC, along with some 5-land stations in EL16 and EL17. Remember the diurnal pattern and the fact that *Es* may often form at the same spot the next day? This opening "foreshadowed" the massive *Es* and TEP opening that occurred March 9th and 10th. That opening is the subject of another article.

Summary to Date of March 2005 *Es*

Historically, March is the month with the fewest *Es* openings reported. For years, Pat Dyer, WA5IYX, has kept a detailed log of FM commercial broadcast-band stations he has heard via *Es*. Reviewing his loggings, there have been many years with *no Es* heard during the month of March. March is truly the "doldrums" for *Es*. For the 1990s decade, Pat reports March *Es* only in 1996 for two days and 1998 for one day. For the '80s,

Pat observed 495 minutes of *Es* in March 1983. The other months of March in the 1980s had either no *Es* or only very brief (less than 1 hour) openings.

Pat's loggings are for the 88 – 108 MHz FM broadcast band. There may be some *Es* openings that do not reach 88 MHz or above, so Pat's log may miss those 6-meter *Es* openings where the MUF barely gets above 50 MHz. Pat's data may not always be an accurate indication for the 6-meter band. However, I believe it gives a good overall estimate of the *Es* openings that would support 50-MHz propagation.

For March of 2005 I estimate from 0000 UTC March 1st to 0300 UTC March 9th there were over 35 hours of 50-MHz *Es* worked in the continental United States. From research based on past 6-meter reports and WA5IYX's detailed commercial FM broadcast logs, the first nine days of March 2005 appear to have had more 50-MHz *Es* than any other March recorded. In addition, the *Es* formed links to TEP to South America. Thus, terrestrial DX over thousands of miles was possible on 6 meters over five years after solar Cycle 23's peak with a solar flux below 100.

What is Causing All the Off-Season *Es*?

Good question. I do not know the answer. Indeed, scientists do not have a detailed explanation for how *Es* openings form nor a detailed method of predicting it. They do have some understanding of the mechanisms. Ken, WB2AMU, and I are developing an article for *CQ VHF* about "aurora-associated *Es*." I observe that many of the 2005 "off-season *Es*" openings occurred a day or two after minor geomagnetic storms with aurora. It seemed as if the aurora "sparked" the *Es*. Read our article and "you decide." In addition, Ken notes that 1996 (which had several major off-season *Es* events) "was a quiet year in terms of geomagnetic activity, particularly the first three months of that year, when the *K*-index did not exceed 4." January 2005 was a very active month, with many CMEs (coronal mass ejections) and the largest proton storm of solar Cycle 23. There have been numerous minor aurora events in February and early March. Suppose the January 2005 CMEs and proton event "seeded" the *E*-layer with additional metallic ions? Ken notes the influx of metallic ions to the *E*-layer helps form *E* clouds. The minor geomagnetic storms may have "pushed" and "aggregated" the metallic ions to the mid-latitudes, where wind shear could then form conventional *Es* after the geomagnetic field settled down.

Another idea is that the Earth's geomagnetic field is changing, and it may influence the *E*-layer. In the April 2005 issue of *Scientific American* is an article on how the Earth's geomagnetic field has changed since 1980. It is not uniform over the Earth. The authors of the article speculate as to whether we are "overdue" for the Earth's geomagnetic field to "flip"—that is, to reverse polarity. Perhaps changes going on in the Earth's magnetic field are influencing the *E*-layer. ■

Notes

1. Ken Neubeck, WB2AMU, and Gordon West, WB6NOA, *VHF Propagation, A Practical Guide for Radio Amateurs* (Hicksville, New York: CQ Communications, 2004).
2. Ken Neubeck, WB2AMU, *Six Meters, A Guide to the Magic Band,* revised 2003 (Sacramento, California: WorldRadio Books).
3. Pat Dyer, WA5IYX, VHF Propagation website page: <http://home.swbell.net/pjdyer/index.html>.
4. Tim Havens, W4TRH, "DXers.info" site: <http://www.dxers.info>.

QUARTERLY CALENDAR OF EVENTS

(from page 41)

Electronic submissions in Word, WordPerfect, or text format accepted by e-mail or CD. Usual drawing formats also accepted with paper(s). Cutoff date for inclusion in the *Proceedings* is September 5. Send an e-mail or write to: Chip Angle, N6CA, P.O. Box 35, Lomita, CA 90717-0035; e-mail: <n6ca@ham-radio.com>. Contact Chip as soon as possible with an abstract or a general idea to help the conference plan activities. Details go to: <http://www.microwaveupdate.org.>

Meteor Showers

May: This month's minor showers include the following and their possible radio peaks: *e-Arietids,* May 9, 0700 UTC; May *Arietids,* May 16, 0800 UTC; and *o-Cetids,* May 20, 0700 UTC. This information courtesy the International Meteor Organization and its website at <http://www.imo.net>.

June: Between June 3 and 11, the *Arietids* meteor shower will once again be evident. This is a daytime shower with the peak predicted to occur on June 8th. Activity from this shower will be evident for around eight days, centered on the peak. At its peak you can expect around 60 meteors per hour traveling at a velocity of around 37 km/sec (23 miles per second).

On June 9 the *Zeta Perseids* is expected to peak. At its maximum it produces around 40 meteors per hour. On June 28 the *Delta Aquarids S* shower is expected to peak. The *Bootids* are expected to make a showing between June 26 and July 2, with a predicted peak on June 27. On June 29 the *Beta Taurids* is expected to peak. Because it is a daytime shower, not much is known about the stream of activity. However, according to the book *Meteors* by Neil Bone, this and the *Arietids* are two of the more active *radio* showers of the year. Peak activity for this shower seems to favor a north-south path.

July: This month there are a number of minor showers. The most intense, the *delta-Aquarids,* is a southern latitude shower. It has produced in excess of 20 meteors per hour in the past. Its predicted peak is around July 28.

August: Beginning around July 17 and lasting until approximately August 14, you will see activity tied to the *Perseids* meteor shower. Its predicted peak is around 1700–1930 UTC August 12.

For more information on these and other meteor shower dates, please see <http://www.imo.net>.

Photo D. The dish is attached to the feed support by a 2" × 2" block.

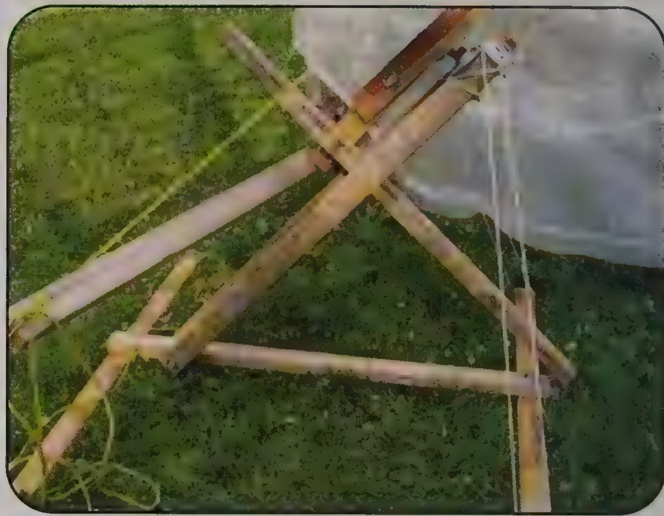


Photo F. The base of the polar mount is made from six 4-foot lengths of 2" × 3" lumber.

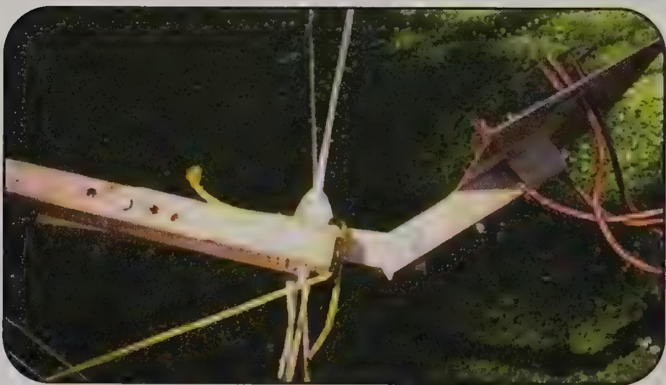


Photo E. The feed is mounted using several supports to allow optimum positioning.

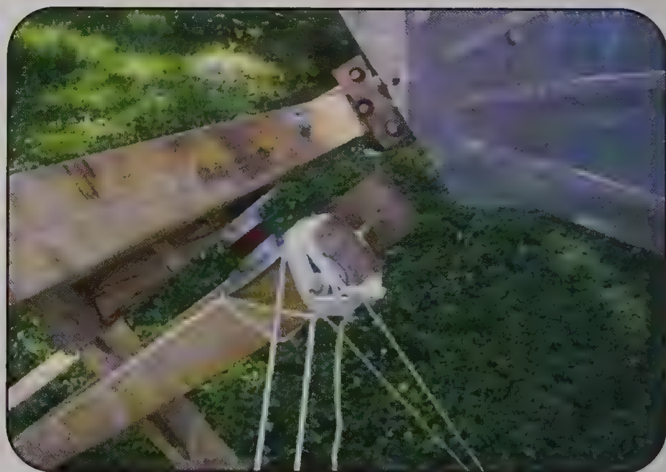


Photo G. A 1-inch diameter pipe nipple is used for the polar axis.

counter this effect, a second 3-foot length of 2" × 3" was added in the direction opposite to the struts and at a right angle to the feed support. The feed support was guyed to this to add support to correct its bending, as shown in photo D. The feed support was also used for attaching the dish to the mount.

Feed Antenna

Orthogonal dual dipoles with a quadrature hybrid to produce circular polarization were used as the feed antenna. Dual dipoles were chosen because of their relatively small size. (An IMU horn would be an excellent choice for a feed antenna but would add significantly to the feed's size and weight). The feed was attached to an about 1-foot length of 2" × 2". This was attached to a second approximately 1.5-foot length of 2" × 2" using a single 3/8-inch bolt, which was in turn attached to the feed support by another single 3/8-inch bolt. Extra mounting holes were drilled in the feed support to allow the position of the feed to be raised or lowered. This arrangement provided several degrees of freedom in adjusting the position of the feed for optimum performance. Feed-mounting details are shown in photo E.

Polar Mount

The offset dish can easily be mounted with a conventional Az-El mount, but also lends itself to polar mounting. Polar mounts have two axes of rotation. The main axis is the polar axis, which is aligned with the North Star. This axis is elevated to an angle equal to the latitude and pointed to true north. The moon can usually be tracked for many hours by changing only the polar axis. This can be advantageous when manually tracking the moon, as is common for portable operation. The other axis is declination. For amateur-size dishes, the declination needs to be set only once a day. It was decided to use a polar mount.

The polar mount was constructed from six 4-foot lengths of 2"×3" lumber. The centers of two of these lengths were attached to a third length to form a base as shown in photo F.

Bolts and nuts were used to attach the lumber. A hinge was secured to one end of the third length, and the end of a fourth length was attached to the other side of the hinge. Two additional lengths were attached on opposite sides to the other end of the base (third length) using a single long 3/8-inch bolt. These two lengths can be moved up and down. The fourth length is positioned between these two lengths. It can be secured at any desired angle (90° latitude) by bolting the open ends of the two lengths together as shown in photo F.

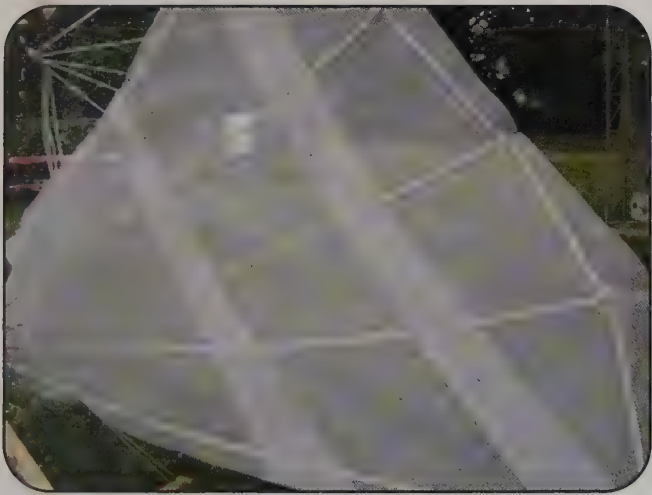


Photo H. Aluminum screening is tied to the struts using wire.

A 1-inch long, 1-inch diameter pipe nipple was used for the polar axis. This nipple was attached to a short (about 1.5 feet) length of 2" × 3" using a pipe flange, and this short length was attached to the dish's feed support with a single $^{3}/_{8}$-inch bolt. The angle between the short length and the feed support is the declination angle of the mount and can be set using the $^{3}/_{8}$-inch bolt. The rotation of the pipe flange on the nipple is used for the polar rotation. A second pipe flange was used to attach the other end of the nipple to the polar mount. This second pipe flange is attached near the top to one of the two parallel members of the polar mount as shown in photos F and G.

One of the limitations of this polar mounting arrangement is that the dish cannot rotate through zenith. The mount blocks the dish. The solution to this problem is to unbolt the dish and flip it 180°. This switch takes only a minute or two and allows horizon-to-horizon moon track except the right near zenith.

Covering

The dish is covered with aluminum screening. This material is available in the U.S. in 3-foot wide by 25-foot long rolls, which is sufficient to cover the dish, for relatively low cost. The screening was first rolled over the top of the stressed dish and cut to the required size. The remaining screening was flipped over to match the cut end with the shape of the dish and rolled over the center portion of the dish. This process was repeated a third time for the bottom section (photo H). One of the extra corner pieces from the top was used to cover the small remaining area at the bottom (vertex) of the reflector. The screening is attached to the struts using small gauge (~ #24) wire. The wire is run through the mesh and around the struts and then wrapped (tied) together. The process of attaching the mesh takes only a few minutes. The aluminum mesh can be removed and rolled around the 4-foot 2" × 3" members from the mount during transport/shipping.

Testing

The offset dish was originally constructed in a single weekend for use on a very hastily planned DXpedition to Bermuda. As events turned out, the power amplifier to be used failed two days before departure and plans for 23-cm operation had to be cancelled. I did test the dish for sun noise, however. The dish appeared to work as planned and yielded >8 dB of sun noise. This was >3 dB more than the 15-foot loop Yagi that was to be our backup antenna.

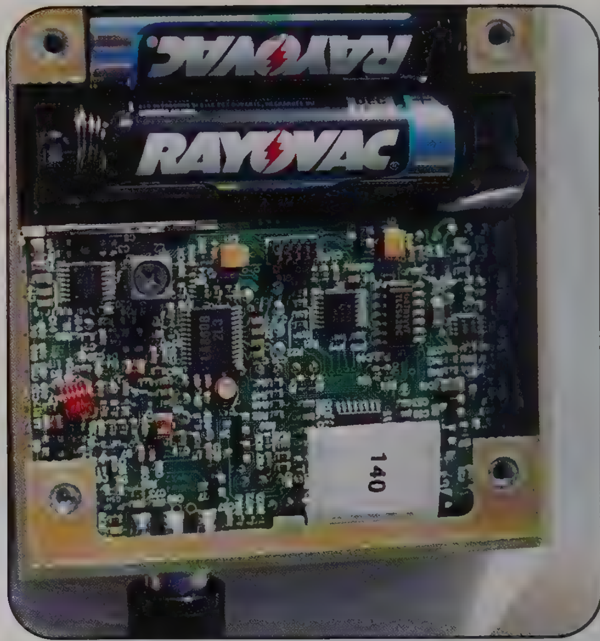
Conclusion

The offset dish described in this article is not considered a final design. It is intended to be a starting point that can be modified and tailored to specific station needs using available materials. It does offer a relatively inexpensive and simple way of obtaining an antenna for portable EME operation on 1296 MHz. It provides performance equivalent to about an 8-foot diameter parabolic dish, yet can be disassembled into a small, lightweight package. ■

Notes

1. A. Katz, "Small Station EME on 70 and 23 cm Using JT44/65"; <http://www.nitehawk.com/rasmit/jt44_50.html>.
2. B. Fritsche, "DL3OCH Report," "432 and Above EME Newsletter," May 2003; <http://www.nitehawk.com/rasmit/NLD/eme0403.pdf>.
3. B. Fritsche, "DL3OCH Report," "432 and Above EME Newsletter," March 2004; <http://www.nitehawk.com/rasmit/NLD/eme0305.pdf>.
4. P. Wade, *W1GHZ Online Microwave Antenna Handbook*, Chapter 5; <http://www.w1ghz.cx/antbook/app-5a.pdf>.
5. A. Katz, "20' Portable Stress Dish," "432 and Above EME Newsletter," October 1980; <http://www.qsl.net/pa3csg/Boek/BoekH3/art3-8.htm>.

The Sniffer with an Arrow antenna.



A peek inside the Sniffer shows all the circuitry contained in this tiny box.

sound of high-frequency interference by tuning into these broadband signals using the Sniffer on 121 MHz AM.

Okay, want more? The #7 sync button is used to synchronize the receiver for use in international-style ARDF (Amateur Radio Direction Finding) foxhunting for a 1-minute-cycle, five-transmitter system. When the sync mode is on, the Sniffer will generate three short beeps, giving a 10-second warning that the current transmitter's cycle is about to end. If the Sniffer is currently receiving at range 1 or lower, at 4 seconds before the completion of the current transmitter cycle the Sniffer will broadcast a number of beeps corresponding to the number of the transmitter in the cycle that is about to commence. The pitch of these beeps is set slightly lower than the 50-second beep. The display also briefly flashes the number of the next transmitter. This way you know where you are in the 5-minute cycle.

In the band-scan mode the Sniffer will hunt for the highest signal between two frequencies stored in memory channels 5 and 6. The highest signal found is stored in Channel 4. The scan will ignore any signals within approximately 10 kHz of the frequency stored for Channel 1, and the signal must be detectable at range 2 or higher to be stored. This is useful when there are many hidden Ts on many different frequencies.

There are many other features in the Sniffer that can make your T-hunting more precise. You can select how fast the rising or falling tone reacts when it goes over scale. You can check to see how long your receiver has been turned on and also double check remaining battery power. The volume control lets you set the volume exactly where you want it, with or without earphones. You can even select four levels of filtering, depending on what mode you are sniffing. In other words, for the expert, advanced ARDF operator the unit has many functions in addition to those a beginner would use.

The Simple Approach

The equipment can also be configured specifically for beginner groups who want simple operation and no problems if they accidentally push a button. That is what we did for our introduction of foxhunting to the Malibu Handi Ham organization last March. We had Handi Ham members quickly finding the hidden Ts. Some were visually impaired. Others had total hearing loss; they went by numbers as well as the feel of the difference in pitch coming out of the small speaker.

Antennas

The three-element Arrow antenna for 2 meters worked great with the Sniffer. Arrow also make a three-element model for 121.5 MHz ELT rescue work. Don't try to use a 146-MHz Arrow antenna on 121.5 MHz, as the frequency span is too far away.

Remember, too, that you can use body-shielding techniques with just a little rubber-duck antenna or a telescoping whip and do the "T-hunt twirl" to find the body null in the direction of the hidden transmitter.

Summary

To learn more about what Bryan Ackerly, VK3YNG, has developed, go to his web page, <http://www.foxhunt.com.au>, or e-mail him at <backerly@bigpond.net.au> and include the word "Sniffer" in the subject line. Bryan is a one-man expert who builds and markets these Sniffers, so give him a couple of days to respond to your questions. Follow his specific details on how to order the Sniffer for overseas shipment to the U.S.

I have exchanged several e-mails with Bryan, and he is a down-to-earth T-hunter who wants to put both fun and new technology into the art of finding the hidden transmitter. As for me, I use the Sniffer for noise detection when I'm not out in the desert at Quartzsite enjoying the fun! ■

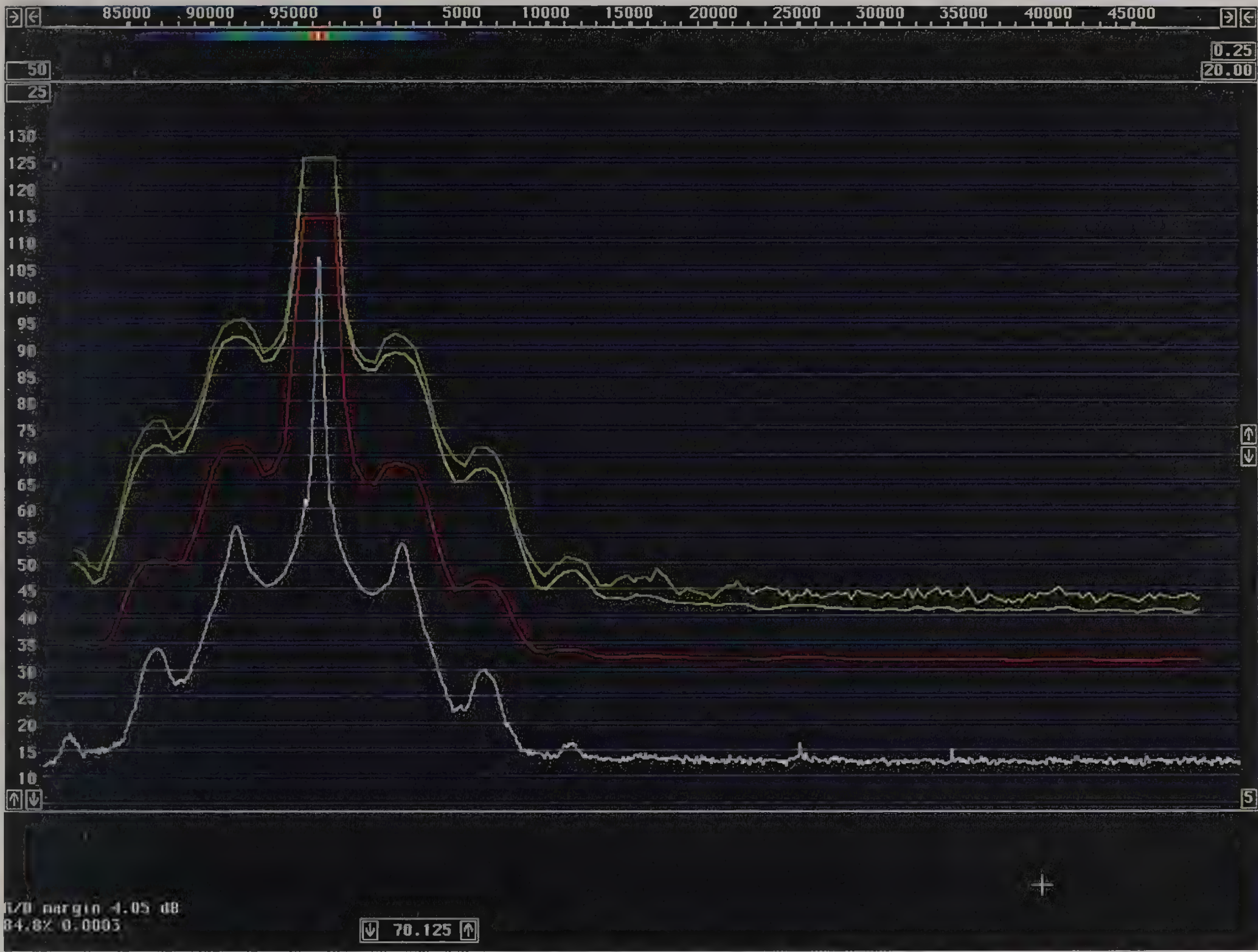


Figure 9. The spectrum of a IC706MKIIG on 14 MHz. The keying speed is 55 Hz and the duty cycle is about 25%. The keying clicks disappear if the key-up time is made very short. The mode is BK with a long delay time to ensure QSK is inactive.

that they should not occur at all! Any observation that they *do* occur is an indication of a design error. Compared to that, whether they are observed in a bandwidth of 1 kHz (2753P), 2.4 kHz (Linrad), or 3 kHz (8651A) is really not very important. This illustrates the difference mentioned earlier between a production or type-acceptance test, and a development or review test. The first needs strict protocols and calibrated equipment. The second does not; it only needs resourcefulness to seek out bad performance caused by design errors, and an unwillingness to accept poor performance.

Keying Waveforms and Key Clicks

To illustrate what this all means I have made some measurements on keyed CW waveforms. Figure 2 shows the time-domain waveform of a keyed signal at 14 MHz, and figure 3 shows the same signal as it looks on the 2753P screen at a resolution bandwidth of 100 Hz.

Figures 2 and 3 were produced with a HP8657A signal generator by feeding the AM modulation input with a square wave through an RC filter. These waveforms are identical to the waveforms that have been presented for many years as "the optimum keying waveform" in the *ARRL Handbook*. This is incorrect, because simple RC shaping is inadequate; good transmitters use much better solutions.[6] The problem is that the keying clicks only decrease by 12 dB each time the frequency offset is doubled. It may not look so bad in figure 3, but the limited dynamic range of a normal spectrum analyzer does not really show what this signal sounds like on the bands . . . the keying sidebands extend on and on. The 2753P spectrum shows the average power in 100-Hz bandwidth, but the peak power is higher—and it increases by 6 dB for a doubling of the bandwidth.

Figure 4 shows the same signal as it looks on the zoomed-in Linrad screen. The keying waveform has the same time for key up as for key down, the separation between the keying clicks is 4.5 ms, and every second pulse is a key down while the ones in between are key up. The key-up pulse and the key-down pulse are equal in amplitude, but they are opposite in phase.

When the FFT spectrum is computed over a long period of time, there will be many pulses within the computation time slot. As a result, one will not see the spectrum of an individual pulse; one will see narrow spectral lines that are separated by the pulse repetition frequency. Every second spectral line is weak, because every second pulse is in antiphase.

Another way of thinking about figure 4 is that it shows the carrier and the mod-

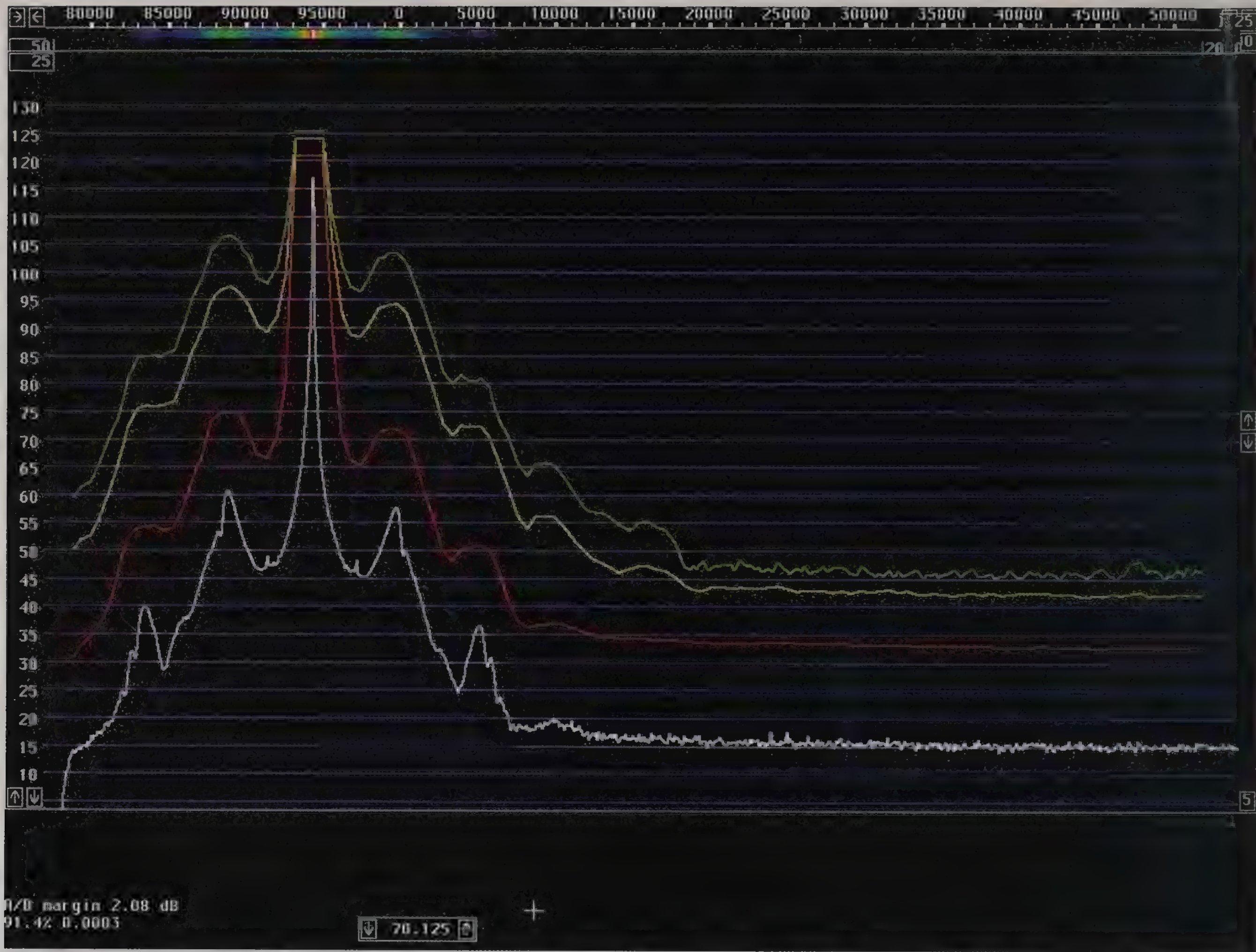


Figure 10. The spectrum of the IC706MKIIG when hand-keyed at 14 MHz in full break-in mode.

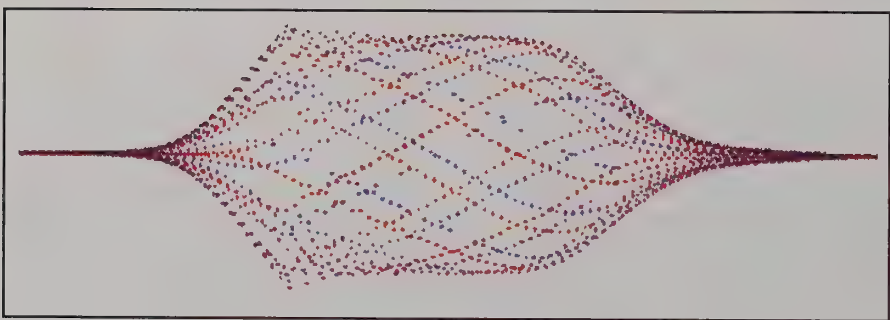


Figure 11. The time-domain function of the IC706 when keyed in full break-in mode. In this mode the ALC loop has to make a large gain adjustment at every key down, as compared to the semi-break-in mode of figure 8, and therefore the amplitude gets modulated by an oscillatory behavior in the ALC loop, corresponding to nearly 15% AM modulation at a frequency of about 5 kHz. This is the cause of the sidebands visible in figure 10.

ulation sidebands of an AM transmitter that is 100% modulated with a square wave that has first been filtered through a single RC time constant. The sidebands are symmetrical, so the keying clicks are equally bad at both sides. The sideband spectrum at each side of the carrier is, of course, the spectrum of the modulating signal, namely the keying waveform. A perfectly symmetric square keying waveform does not have any even harmonics, so as one would expect, the keying sidebands corresponding to even-numbered harmonics of the keying waveform are weaker than those of the odd-numbered harmonics. As expected, the amplitude of the side carriers decrease by 12 dB each time the frequency separation is doubled, because that is the rate at which the overtones to a square wave roll off in a simple RC filter.

When keying at 250 wpm, the 23-dB bandwidth is about 600 Hz according to the *ARRL Handbook.*[7] One-hundred times further out, at 60 kHz, one consequently would expect the level of the keying clicks to be 40 dB lower or at –63 dB relative to the desired signal. This is a terrible QRM level! High-speed CW stations absolutely should not use this primitive RC shaping for keying waveforms!

At lower speeds the keying sidebands are more closely spaced and there are obviously fewer keying clicks in a given time. Also, the sidebands will smear out,

and dashes and word spacings will form components of lower frequencies that make the spectrum look very different in high resolution. When the bandwidth of the spectrum analyzer is set wider, several of the keying sidebands will pass through the filter simultaneously. These signals have a particular phase relation and they add to form pulses—one for each make or break of the Morse code. In a wide bandwidth, the spectrum does not depend on what is being keyed. The average noise level created is simply proportional to the keying rate (the number of clicks per second), but the peak noise level is independent of the keying rate. Each key up or key down is a separate event that produces a wide-spectrum pulse that is unaffected by other keying events.

Figure 5 shows the Linrad screen in "TX test mode." This is a mode I added to Linrad in order to have all the transmitter measurements done simultaneously. Here one can see the average spectrum and the peak hold spectrum at the same time. There is also an averaged peak spectrum with a time constant of about 1 second. Transmitters occasionally may emit short splatter bursts depending on the modulating voice. The peak hold will just go to the peak value the first time, and one will not see how often it happens unless the reset button is pressed each time. The averaged peak spectrum with a 1-second time constant shows these splatter bursts well, and it helps to find out how to speak into the microphone to make them really bad. One can then record the average and the peak hold spectra for evaluation in a worst-case situation.

As can be seen in figure 5, the peak power of the keying clicks is 87 dB below the peak power at a frequency separation of 50 kHz, while the average power is 98 dB below the peak power. The bandwidth is 2.4 kHz, so the average interference power is –132 dBc/Hz. The reason for much better results than expected as shown in figure 11 in the *ARRL Handbook*[7] is that the keying for this test is far softer than one would use in real life at a dot rate of 110 Hz (132 wpm, 660 lpm).

This dot rate used in figures 2 to 5 is quite realistic for CW meteor scatter, but such a high speed was chosen primarily to allow both the rising and the falling edges to be seen in detail in figure 2 and to make the spectral lines well separated in figures 3 and 4.

The *ARRL Handbook* claims that the simple RC filter used here would be appropriate for keying rates on the order of 30 wpm if it were implemented in an amateur transmitter. However, the discussion of figures 2 to 5 shows that keying a transmitter like this is not acceptable. Using a simple RC filter at high keying speeds will cause excessive and completely unnecessary bandwidth and too much interference to fellow amateurs. At a modest keying speed the time constants can be made five times longer and then the spectrum will be five times narrower, so the keying clicks will produce an average power level of –132 dBc/Hz at a frequency separation of 10 kHz. This is similar to normal sideband noise levels, so it would not be a problem if the keying were perfect otherwise.

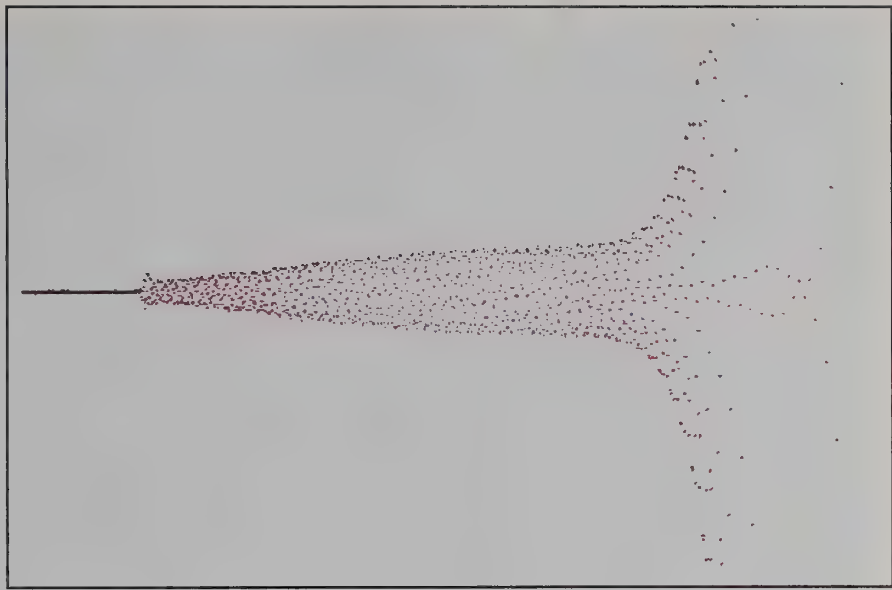


Figure 12. The onset of the keying waveform in full break-in mode for the IC706MKIIG at 14 MHz. The magnification is 40 dB relative to figure 11.

There is still another problem, however: The output RF voltage has to follow the keying voltage strictly proportionally all the way from zero. Any non-linearity will increase the bandwidth. In a typical form of non-linearity, the output voltage to the antenna will be zero, not only for zero keying voltage; it will stay zero for small values of keying voltage and only then start to grow linearly. The output is identical to the output that would be obtained from a perfect AM modulator that is fed from a non-linear amplifier with distortion at the onset of the waveform. This is similar to cross-over distortion in audio amplifiers, which creates harmonics of modest amplitudes but extending to a high order. In other words, this kind of non-linearity will increase the levels of the keying clicks, particularly at large frequency separations. A similar effect can be obtained by feeding a keyed signal through unkeyed class C amplifiers. Considering the levels of high-order suppression for sidebands required in amateur radio, all of these effects are significant.

A good linear relationship between the voltage output from the keying filter and the RF voltage at the antenna therefore is very important. I have discussed the shortcomings of the simple RC filter in detail so that you can understand the basic problems. What you see in figures 2 to 5 is real-life data produced by actually keying an RF signal. The theory, of course, is well known and predicts exactly what one can see from the figures. A detailed theoretical treatment is presented in Kevin Schmidt, W9CF's article "Spectral Analysis of a CW Keying Pulse."[8] The very basic facts are as follows: *Each individual key-up and key-down transition generates a full-amplitude, full-spectrum click. The only thing that is "worse" about HSCW is that there are simply more clicks.* The meaning of "full-spectrum" here is, of course, the full frequency response of the keying filter, mirrored around the carrier, and broadened by any distortion due to the non-linearities between the keying waveform and the RF-output voltage waveshape.

The problem with using very-high-speed CW for meteor scatter is that one has to modify the keying circuits for much shorter time constants in order to have any keying at all, thereby making the rig awful at *all* keying speeds. To avoid this it may be much better to key

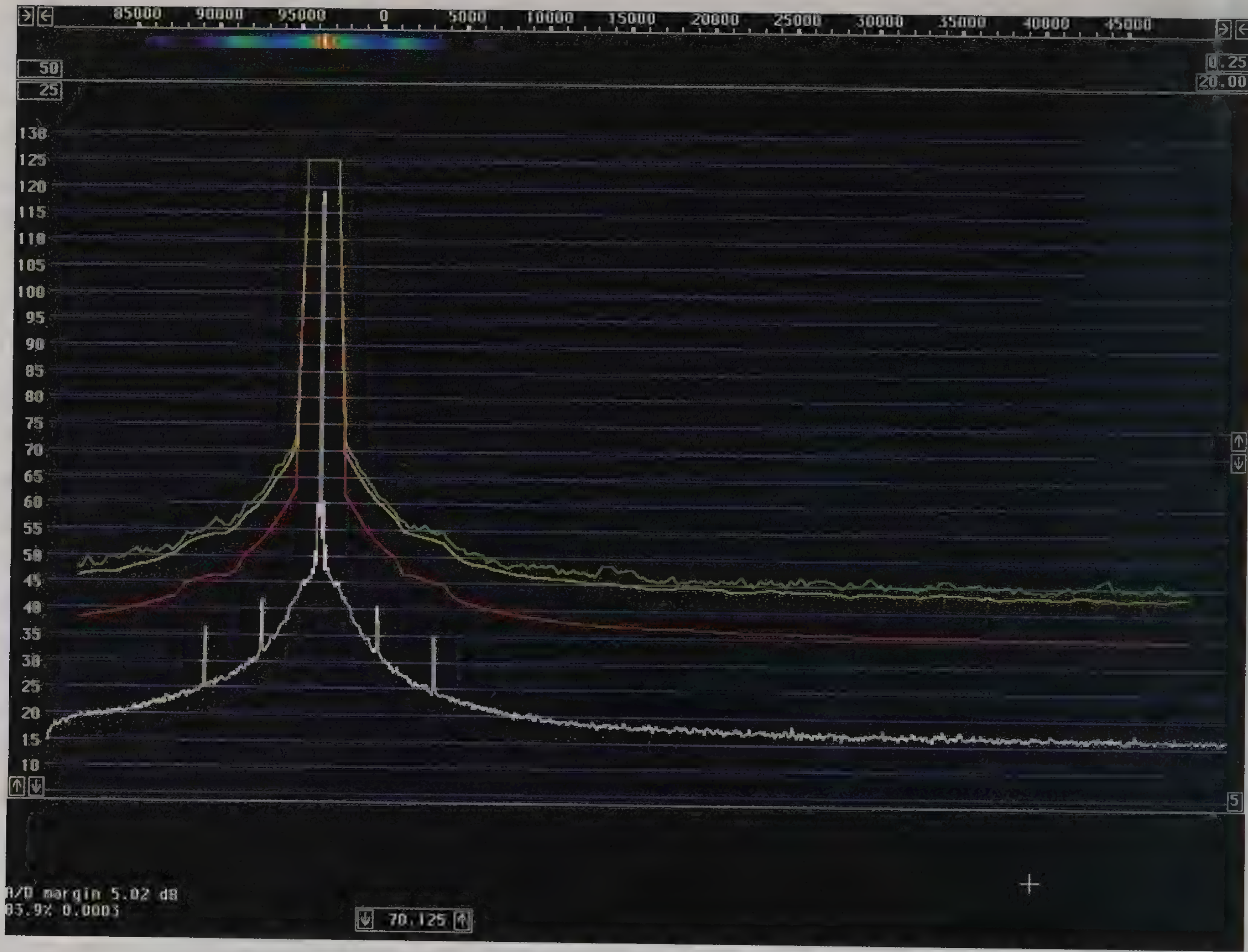


Figure 13. The IC706MKIIG without keying on 14 MHz, for comparison with figures 9 and 10.

an audio tone and feed it into the SSB microphone input. The SSB filter will then limit the bandwidth to 1.8 kHz. By setting the drive level properly so that ALC circuits do not distort the waveforms, one can produce excellent HSCW.

It is not necessary to look at both the time domain and the frequency domain to decide if the keying is okay or not. One can look at either the time domain in figure 2 or the frequency domain in figure 4. Both of them contain all the information, because both are generated from the same RF signal and one is the Fourier transform of the other. (A few details here: Actually, the time function is the backwards transform of the frequency spectrum, but forward and backward transforms differ only in the phase. Otherwise it is the same algorithm. Also, figure 4 is not really the Fourier transform; it is the power spectrum of the transform, but the relevant information is still there.)

A signal that is wide in the frequency domain is narrow in the time domain and vice versa. The width in the time domain is the width of the envelope; the sinewave under the envelope gives the frequency of the signal, which gives the peak position in the frequency domain. The Fourier transform is a linear transformation, which means that a signal can be split into several parts that sum up to the signal itself. The sum of the Fourier transforms of all the parts will then sum up to the transform of the total signal. A single Morse code transition like the rising edge in figure 2 has a spectrum that looks like a line that joins all the peaks of the spectral lines in figure 4 but with smaller amplitude. When the Fourier transforms of many such individual transitions are summed, the phase of all of them will be equal at frequencies corresponding to frequency offsets that are multiples of the repetition rate. At frequencies in between the contributions from the different pulses cancel because they have opposite phases. As explained in W9CF's "Spectral Analysis of a CW Keying Pulse"[8] the width of the time function is the width of the transition from on to off or off to on. The length of the key-down and key-up periods will only affect the repetition rate and the spacing of the sidebands in the frequency domain.

An exponential RC-generated rise time such as in figure 2 gives a spectrum that rolls off by 12 dB per octave. However, the optimum shape of the pulse for a Morse code dot is a Gaussian. The Gaussian shape is special, because it is the mathematical function that minimizes the width simultaneously in both the time domain and the frequency domain; the Fourier transform of a Gaussian is another Gaussian. (This is why the HP8591A uses Gaussian filters. They allow the fastest possible sweep without loss of amplitude accuracy. The TEK2753P with its more rectangular filters has to

sweep more slowly, but it allows much better viewing of weak signals close to a strong one.) For a single transition, key down or key up, the optimum shape is a Gaussian "error function." This is an S-shaped function that avoids the sudden transitions and will produce a Gaussian spectrum shape with the fastest possible roll-off—10 dB per 30-Hz increase in the frequency separation at typical amateur keying speeds. (For details see note 8, equation 20, and figure 5.)

Modern rigs typically generate CW by keying a signal which is then passed through the SSB filter, and therefore the keying clicks should not reach outside the bandwidth of the SSB filter. This is one way of producing nearly ideal rise and fall waveforms. One example is the ICOM IC706MKIIG, which generates the waveform of figure 6 on 144 MHz when keyed at 55 Hz. A comparison with figure 2 immediately shows that this keying is much better. The envelope looks like the output of a higher-order filter, and it does not have the steep onset of a square wave filtered through an RC filter.

The spectrum of the keyed IC706MKIIG corresponding to figure 6 is shown in figure 7. In a comparison between the keyed spectrum and the continuous carrier of this station, one can find that the interference level from the keyed rig is below the interference of the unkeyed carrier at frequency separations above 700 Hz.

That is the point where the keying clicks disappear into the sideband noise of the unkeyed carrier. Note that the keying sidebands fall off at a rate of about 12 dB for every 200 Hz, while the simple RC filter gives sidebands that fall off by about 12 dB for a doubling of the frequency separation. At large frequency separations this makes a big difference, and the keying spectrum of figure 8 is much narrower than the spectrum of figure 4, by much more than the factor of 2 that would be produced by the simple difference in time constants.

It is quite clear that excellent keying is possible—very low keying clicks in combination with a waveshape that sounds sharp and clear and also has the potential to go to high keying speeds. The simple RC filter belongs to the era of cathode-keyed vacuum tubes; there is no reason

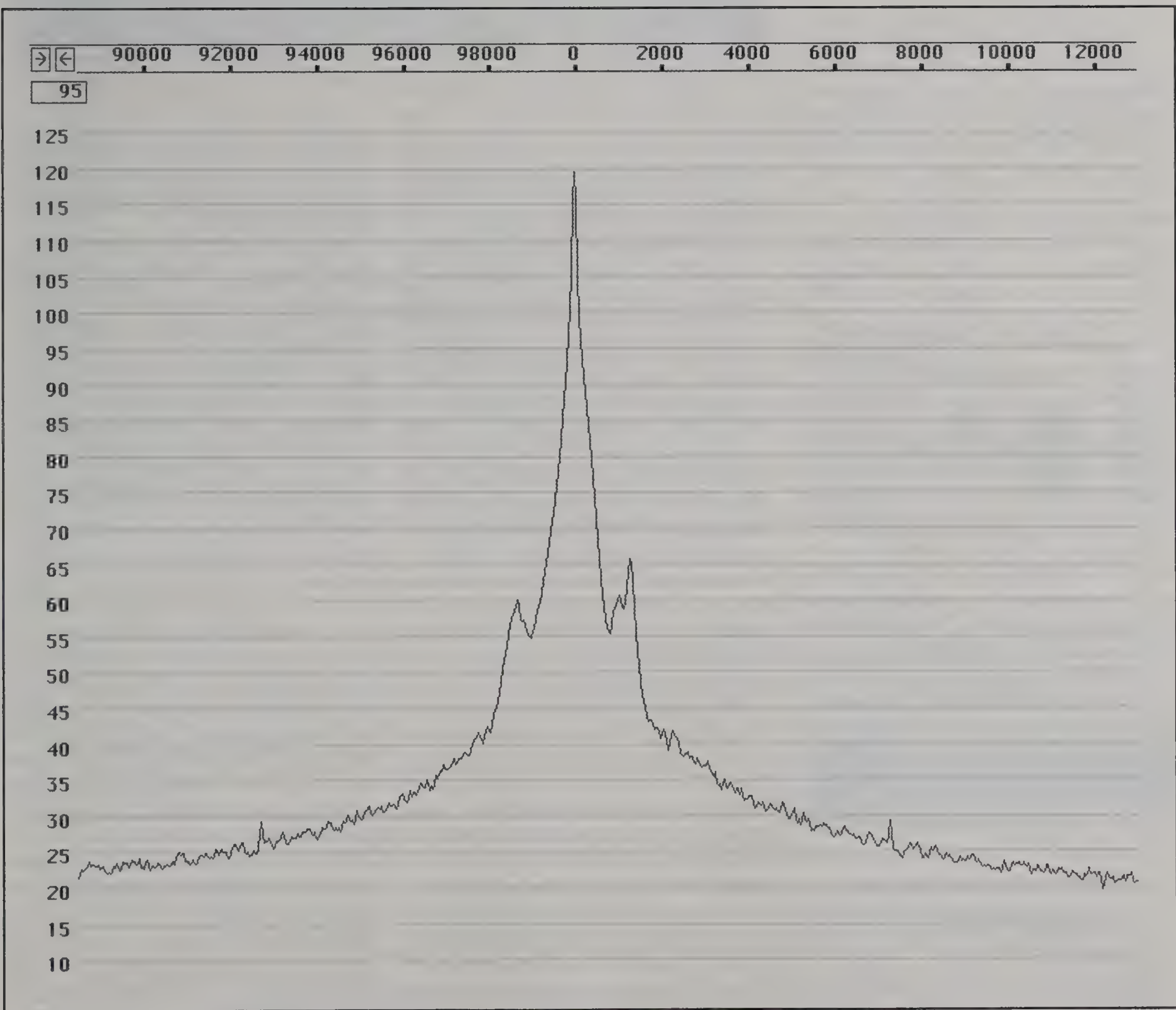


Figure 14. Expanded average-power spectrum of a keyed FT1000D on 14 MHz. The keying is 50% duty with 25 dots/sec. The FFT bandwidth is 50 Hz.

to use such a primitive filter in modern equipment—no reason, that is, except for poor design.

Effects of ALC

The discussion about CW waveforms up to this point was intended to show principles of normal keying. In the real world there are additional complications. Figures 8 and 9 show the time-domain waveform and the spectrum of the same IC706MKIIG when it is keyed on 14 MHz. One clearly can see something happen that reduces the output power, after it has risen above the steady-state value it will have during most of the key-down time. Most probably this is the ALC setting the power at the desired level, but with some overshoot.

The spectrum shown in figure 9 is the Linrad TX test-mode display corresponding to figure 8. The keying rate is lower compared to figure 5, so there are fewer keying clicks each second. Therefore, the peak levels are 25 dB above the average power levels in 2.4-kHz bandwidth. The peak hold and the 1-second peak average curves are close to each other, differing only by about 3 dB. This is because the peak level is determined within the time spanned by one FFT (actually the time between the –6-dB points in the FFT1 window function) and there is one new maximum value about every second.

On the air, the keying clicks at these levels make a 10-kHz segment of the 14-MHz band useless. The peak power of each key-down click is only 34 dB below the full power of the carrier at a frequency separation of 5 kHz. I think the reason for this bad behaviour is the misuse of the ALC that seems to be a common plague in amateur transceivers. Figure 8 points in this direction, as well as the fact that the amount of overshoot depends on the time since the previous key-down period. If it is short enough, the ALC voltage does not have enough time to change much and therefore the gain adjustment becomes very small each time a new pulse arrives.

The keyed waveform of the IC706MKIIG in full break-in mode is much worse than that shown in figures 8 and 9. The spectrum is shown in figure 10. This level of keying clicks is not acceptable at all. Not only is the close-range interference level worse than in normal (semi-break-in) mode, there is also a wideband component with a flat spectrum that has peak power levels 75 dB below the carrier in 2.4-kHz bandwidth. An inspection of the time-domain signal shown in figure 11 indicates that the main problem in full break-in is that the ALC voltage is being reset during every single key up, causing the ALC voltage to need a very large change to get the right output power. Keying then produces a damped oscillation at about 5 kHz in the ALC loop, which in turn produces amplitude modulation at a peak level of about 15%, as one can see by close inspection of figure 11. The resulting 5-kHz sidebands have a peak amplitude that is only 23 dB below the carrier, as can be seen in figure 10. It is a general rule (of course) that major deficiencies in a transmitter are well visible in both the time domain and the frequency domain. The similarity of figures 9 and 10 indicates that the keying clicks are created by the same phenomenon.

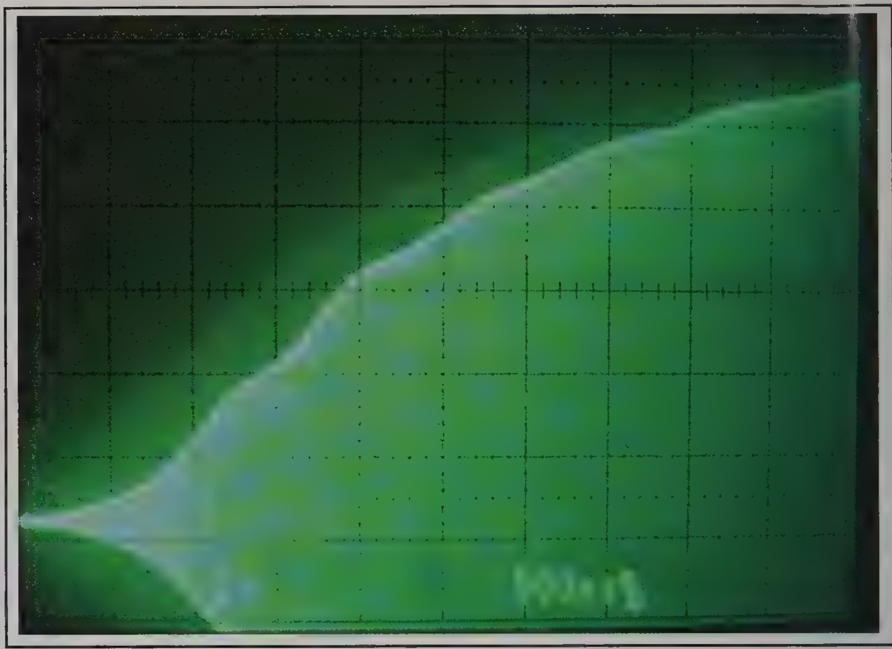


Figure 15. Rising edge of keying waveform of an FT1000D on 14 MHz.

The wideband interference visible in the spectrum in full break-in mode is even more easily understood by inspection of figure 12, which shows the time-domain function at the start of every dot or dash, magnified by 40 dB relative to figure 11. At the moment when the antenna relay contact switches the antenna to the TX, the dot/dash has already started and the power is already at about –70 dB relative to full power. The cure for this problem is easy. The keying is obviously done in at least two stages and they do not have their zero points at the same point on the keying waveform. Just changing the zero point of the keying voltage—that is, causing the power to be turned on too early—will remove this keying click without any adverse effect at all.

Figures 11 and 12 are good illustrations of the principle of additivity in Fourier transforms. The waveform can be written as the sum of three waveforms. The dominating part is the waveform displayed in figure 6. To this is added a pulse with about 15% amplitude, which is a damped oscillation with several peaks at a modulation frequency of about 5 kHz. The spectrum of the main part is, of course, identical to the spectrum of figure 6. The shape is obtained by joining the peaks of the individual spectral lines in figure 6 while the amplitude of the sidebands is lowered by the rate of pulse repetition rates. The pulse structure provides the sidebands at 5 kHz, but the pulses are not quite sinewave in shape, so they contain components of overtones which are sidebands farther away from the carrier. The third component can be seen in figure 12 only. It is a small pulse with very short risetime. The risetime is probably much shorter than one can see in figure 12, because the display is limited by the bandwidth of the Linrad system. This pulse gives a click that has the same amplitude over the entire spectral range, and it is this component of the total waveform that is responsible for the wideband clicks.

When looking at a waveform in the time domain, the bad part is any place

where the second derivative of the envelope is large—in other words, any place where there is a sharp corner. Such places occur at the onset of both key up and key down in the simple RC-shape keying shown in figure 2, but there are no such points in the much better waveshape of figure 6. Large second derivatives may also occur when an amplifier saturates or when the transmitter gain is changed abruptly because of ALC action. Badly designed QSK is another source of large second derivatives, as we see in figure 12.

Figure 13 is a reference spectrum at 14 MHz for the unmodulated IC706MKIIG used for this article. It is neither especially good nor bad, –122 dBc/Hz at 20 kHz, but the difference in the spectra when the carrier is keyed is horrible. On 144 MHz, on the other hand, there is no visible difference between the keyed and the unkeyed spectrum at frequency separations above about 700 Hz, as was pointed out in the discussion of figure 8.

Another transceiver that has a poor reputation for key clicks is the FT-1000 range of transceivers. As often happens with such problems, opinions range from "All [models of] FT-1000 as shipped from the factory click excessively and needlessly" to the complete opposite—denial that any such problem exists. As seen with the eyes of a VHF weak-signal enthusiast, the FT1000 is not so bad, but on crowded HF bands the keying clicks present a real problem to fellow amateurs.

It is (like always) not difficult to adjust components for reasonable rise and fall times. Modifications, sound-clips, and composite spectra of these transceivers before and after modifications can be found on the Internet. [9–11] It seems as if normal variations in component parameters and perhaps other differences cause some difference in rise and fall times for the FT1000 range of transceivers. The unmodified FT1000D I used for this article has a somewhat softer keying compared to that used in reference 9.

The peak hold spectrum in 2.4-kHz bandwidth is excellent, but the high-resolution average-power spectrum reveals clicking sidebands at ±1.2 kHz from the carrier as can be seen in figure 14.

The sidebands are caused by AM modulation on the rising edge, something that is well visible on the oscilloscope, as can be seen in figure 15.

As can be seen from figure 15, the AM modulation starts at an amplitude corresponding to about 5% of the full carrier amplitude. This means that the modulation sidebands at Y' 1.2 kHz appear at about 30 dB below key-down power. The AM modulation lasts about 2 ms, which is 5% (–13 dB) of the keying period time. One therefore would expect the keying click sidebands at –43 dB in a 500-Hz wide filter. In the frequency domain, figure 14, the level is about –60 dB in 50-Hz bandwidth in fair agreement with this rough estimate. At frequency separations above 1.8 kHz there are no key clicks at all, only the carrier sideband noise, which is 50% below its normal level due to the keying at 50% duty.

The 1.2-kHz keying click sidebands of the FT1000D are not at all affected by the ALC. These sidebands are produced by AM modulation in the keying circuitry and the spectrum does not change when the output power is reduced. ■

Notes

1. Leif Åsbrink, SM5BSZ, "Receiver Dynamic Range," *DUBUS* 4/2003, pp. 9–39, and *DUBUS* Book *TECHNIK VI*, pp. 348–378. Also see <http://www.sm5bsz.com/dynrange/rig_compare.htm> and links from there, plus the Fall 2004 and Winter 2005 issues of *CQ VHF*.
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3. <http://www.sm5bsz.com/linuxdsp/linrad.htm>
4. Mike Gruber, WA1SVF, "Improved Transmitted Composite-Noise Data Presentation," *QST*, February 1995. p. 59.
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7. *The ARRL Handbook*, 1994. Figure 11 is on p. 9-9.
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9. <http://www.w8ji.com/keyclicks.htm> and <http://www.w8ji.com/keyclick_mp.htm>
10. <http://www.qsl.net/n1eu/Yaesu/ MPclicks.htm>
11. <http://www.qth.com/inrad/kits.htm>

By Dr. H. Paul Shuch,* N6TX

DR. SETI'S STARSHIP

Searching For The Ultimate DX

Blame It on Rio

"I think I'm seeing something," the intrepid Argonaut† stated on the closed signal verification e-mail list, and then proceeded to post a string of numbers representing date, time, right ascension, declination, frequency, and amplitude. "Anybody care to confirm?"

For a day and a half the e-mails flew freely, with half a dozen amateur radio telescopes trained on the same slice of sky, seeking a consensus. Ultimately, I was asked to proffer an opinion. "On a scale of zero to ten," I confidently proclaimed, "we can give this one a three."

An arbitrary attempt at quantification? Hardly! I was rating a detection on the Rio Scale, SETI's newest metric for assessing the importance of any claimed detection. It's my hope we will join our professional colleagues around the world in making the Rio Scale our measurement standard.

The Rio Scale is an ordinal scale between zero and ten used to quantify the impact of any public announcement regarding evidence of extraterrestrial intelligence. The concept was first proposed in Rio de Janeiro, Brazil (hence its name) by Ivan Almár and Jill Tarter in a paper presented at a major SETI meeting in October 2000. Under their leadership, members of the International Academy of Astronautics worked for two years to refine and perfect the Rio Scale in order to bring some objectivity to the otherwise subjective interpretation of any claimed extraterrestrial intelligence detection.

The Rio Scale was officially adopted by the international SETI community at the October 2002 World Space Congress in Houston, Texas. Within a month The SETI League was applying it to amateur observations. By December we had used it to discredit a blatant hoax. If it continues to catch on as well as the Richter Scale has for earthquake severity, then the public will have little doubt as to the importance of future SETI detections.

Anyone can do a Rio Scale analysis of any SETI signal detection, be it current, historical, or hypothetical. One merely needs to answer four questions about the class of the reported phenomenon, the type of discovery, the estimated distance to the source of the phenomenon detected, and the credibility of the person or organization reporting the data. Crunching the resulting numbers yields a single integer, zero to ten, which we can then report to one another and to the press.

If you have access to the internet with a JavaScript-enabled browser, you are invited to try your hand at an interactive Rio Scale Calculator. Browse to <http:// iaaseti.org> and follow the Rio Scale links. Radio buttons enable you to quickly enter the particulars of the detection being analyzed. The calculator software computes the resulting Rio Scale value for the event under study. Members of the scientific community and the press can use this tool for estimating Rio values during analysis of SETI candidate events, and are encouraged to assign Rio Scale values in quantifying their estimates of the importance of any reputed detection.

Rio	Importance
10	Extraordinary
9	Outstanding
8	Far-reaching
7	High
6	Noteworthy
5	Intermediate
4	Moderate
3	Minor
2	Low
1	Insignificant
0	None

The Rio Scale is an ordinal scale between zero and ten used to quantify the impact of any public announcement regarding evidence of extraterrestrial intelligence. Each numeric Rio Scale value correlates to a subjective measure of an event's importance, from None to Extraordinary.

The Rio Scale is a tool for dynamic, rather than static, analysis. Throughout the life of any candidate SETI event, as research is conducted and verification measures pursued, new information is constantly being made available which will impact our perceptions as to the significance and credibility of the claimed detection. Thus, the Rio Scale value assigned to any SETI detection can be expected to change significantly (either upward or downward) over time. In the case of the Project Argus detection already cited, during the course of a week's observations the assigned value slid from three down to zero, when the source of the signal was finally traced to terrestrial interference.

This one wasn't ET calling home—but it might have been. When "The Call" is finally intercepted and we assign it a high Rio Scale value, I'm willing to bet the detection will have been made by a SETI League member. 73, Paul, N6TX

*Executive Director, The SETI League, Inc.,
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†A participant in Project Argus, The SETI League's all-sky survey.

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